DOSE RECONSTRUCTION FOR THE URALS POPULATION

Joint Coordinating Committee on Radiation Effects Research
Proposal (Protocol) for Continuation of Project 1.1

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1. ABSTRACT

The Mayak Industrial Association (MIA, also known as the Mayak Production Association, or MPA) was the first Russian site for the production and separation of plutonium.* This plant began operation in 1948, and during its early days there were technological failures that resulted in the release of large amounts of waste into the rather small Techa River. There were also gaseous releases of radioiodines and other radionuclides during the early days of operation. In addition, there was an accidental explosion in a waste-storage tank in 1957 that resulted in a significant release (the Kyshtym explosion). The "Techa River Cohort" has been studied for several years by scientists from the Urals Research Centre for Radiation Medicine (URCRM), and an increase in both leukemia and solid tumors has been noted (Kossenko and Degteva 1994). This cohort is the primary focus of collaborative studies, but other cohorts have been suggested for study. These include the "East Urals Radioactive Trace" (EURT) Cohort that was exposed as a result of the Kyshtym explosion and the "Ozersk" Cohort, which consists of the residents in the town housing the workers and their families who were exposed primarily to the gaseous emissions during the early days of the operation of the MIA.

This document consists of two separate proposals for dose reconstructions that are to be undertaken to support sister epidemiologic studies. One is a proposal for a full-scale dose reconstruction for the Techa River Cohort and the EURT Cohort. Individuals doses would be reconstructed for approximately 49,500 individuals in these two cohorts over a time period of four years. This proposal is the result of the first year's pilot-scale project (Degteva et al. 1996), and the methodologies for achieving the dose reconstruction have been worked out in detail. The second proposal is offered as a one-year pilot-scale project for a dose reconstruction for the Ozersk Cohort. Work on the dose reconstruction for this Cohort was also considered in the first year's pilot-scale project, but only in a limited way. At the present time, it is not possible to specify in detail how the dose reconstruction might be done for the Ozersk Cohort; this is the purpose of the proposed pilot-scale project.

2. SPECIFIC AIMS

Techa River and ERUT Cohorts

The specific aim of this proposed study is to reconstruct external and internal radiation doses for approximately 49,500 individuals in these two cohorts. The purpose of the dose reconstruction is to support companion epidemiologic studies of radiogenic leukemia and solid cancers.

Ozersk Cohort

The specific aim of this proposed one-year pilot-scale study is to clarify the possibility of reconstruction of doses to the Ozersk Cohort (who lived in the community next to the Mayak IA)

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* General information on the releases is contained in Akleyev and Lyubchansky (1994).

due to gaseous and aerosol releases over the entire period of its routine operation. This aim can be achieved by solving the following tasks:

- Clarification of availability and evaluation of information in archival records on the dynamics of gaseous and aerosol releases from the MIA over the whole period of its operation.
- Clarification of availability and usefulness of archival records that characterize the meteorological conditions in the area where the MIA and Ozersk are located.
- Clarification of the availability and usefulness of data that characterize the contamination of foodstuffs with radionuclides from 1948 through the present time.
- Clarification of the availability and usefulness of demographic and food-consumption data.
- Determination of the main pathways of exposure during different periods of operation.

3. BACKGROUND AND SIGNIFICANCE

Population exposure in the Urals occurred as a result of failures in the technological processes at the MIA plutonium facility in the 1950's. Construction of the Mayak facility began in 1945 and was completed in 1948. Initially this complex consisted of three main parts: Reactor plant, radiochemical facility, and waste-management facilities (Fig. 1). The major sources of radioactive contamination were the discharges of 2.7×10^6 Ci of liquid wastes into the Techa River (1949–1956); an explosion in the radioactive waste-storage facility in 1957 (the so-called Kyshtym Accident) that formed the East Urals Radioactive Trace (EURT) due to dispersion of 2×10^6 Ci into the atmosphere; and gaseous aerosol releases (about 560,000 Ci of ^{131}I in total) within the first decades of the facility's operation (Fig. 1). The significant portion of activity for the Techa River and EURT consists of long-lived radionuclides, mainly ^{90}Sr (Fig. 2 and Table 1). These releases resulted in the long-lived contamination of surrounding territories (Fig. 3). The predominant radionuclide for operating gaseous aerosol releases was short-lived ^{131}I that resulted from the processing of nuclear fuel for the extraction of Pu. The maximal annual rates, which occurred in 1952–1953, were reconstructed on the basis of technological records by the Mayak team supervised by Dr. E. Drozhko (Khokhryakov et al. 1992) (Fig. 4).

Table 1. Isotopic composition of waste ejected in the Kyshtym explosion (according to Dr. G. Romanov et al. 1990).

Radionuclide	Isotopic composition, %
^{89}Sr	trace
^{90}Sr/^{90}Y	5.4
^{95}Zr/^{95}Nb	24.9
^{106}Ru/^{106}Rh	3.7
^{137}Cs/^{137m}Ba	0.036
^{144}Ce/^{144}Pr	66
^{147}Pm	trace
^{155}Eu	trace
^{239,240}Pu	trace

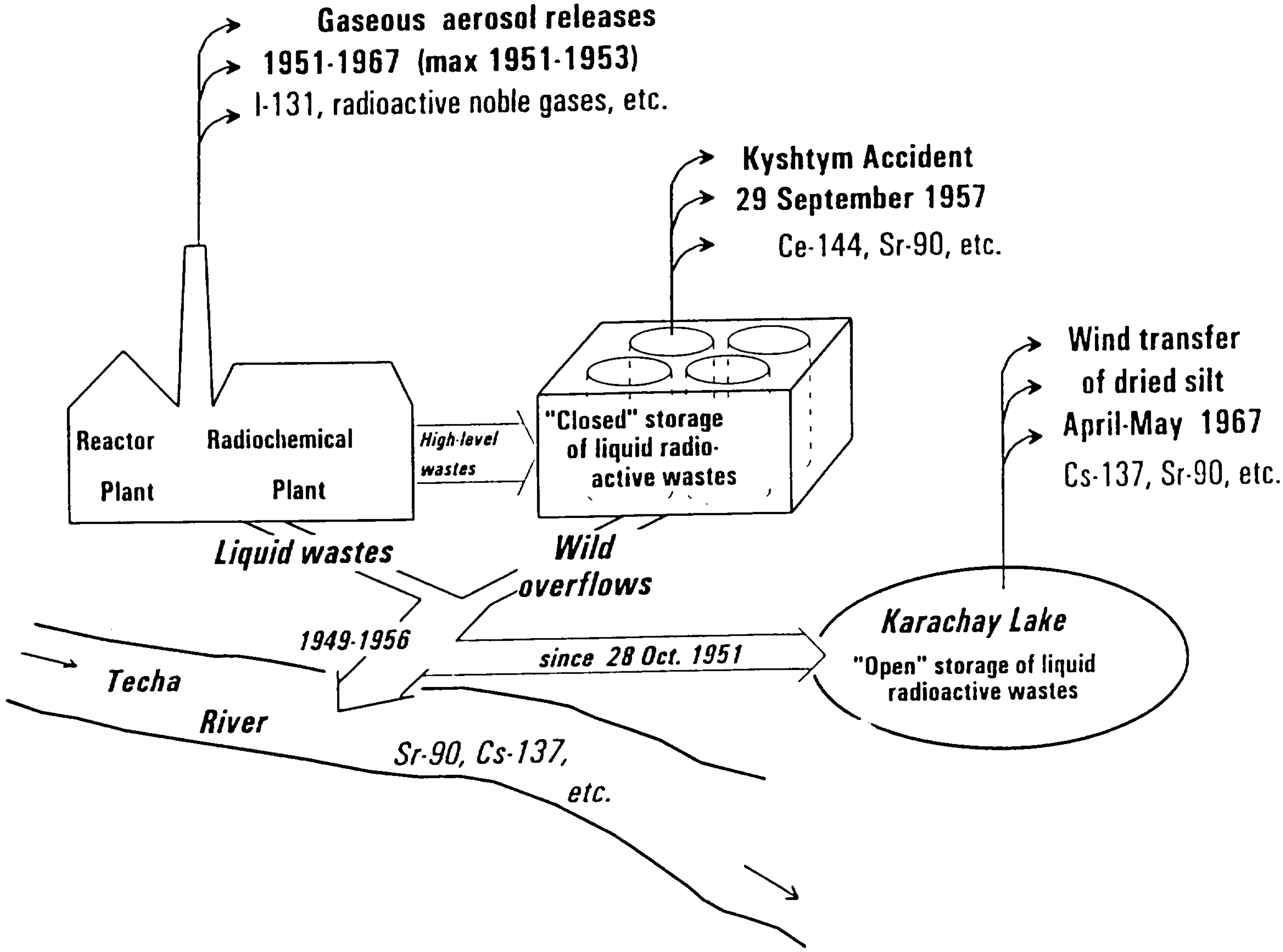

Fig. 1. The Mayak complex and main releases of radioactive materials.

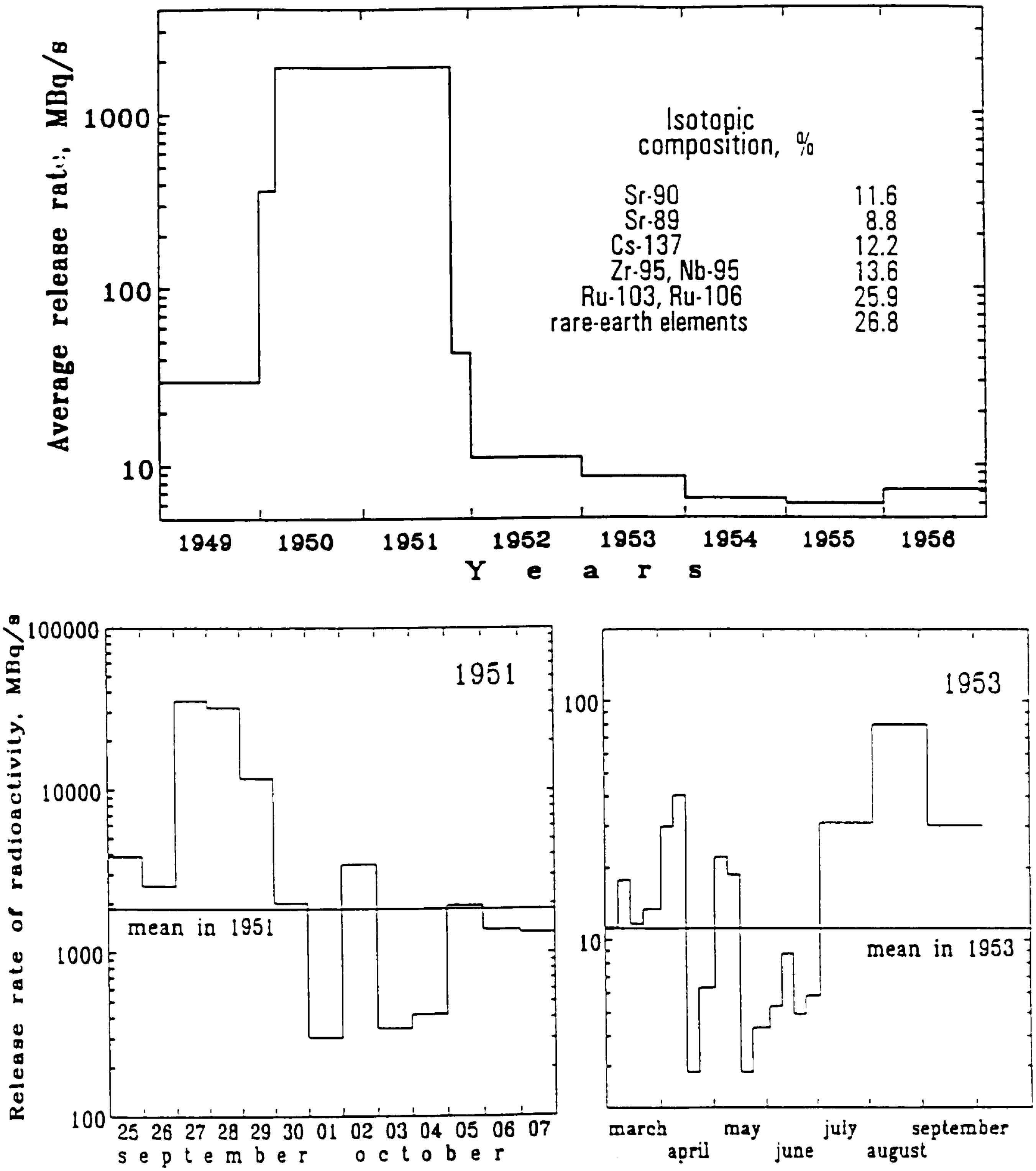

Fig. 2. Releases into the Techa river (according to the data of the Mayak Laboratory, project director D.Ilyin).

THE MAP OF THE URALS REGION
SR-90 Contamination, Ci/km²

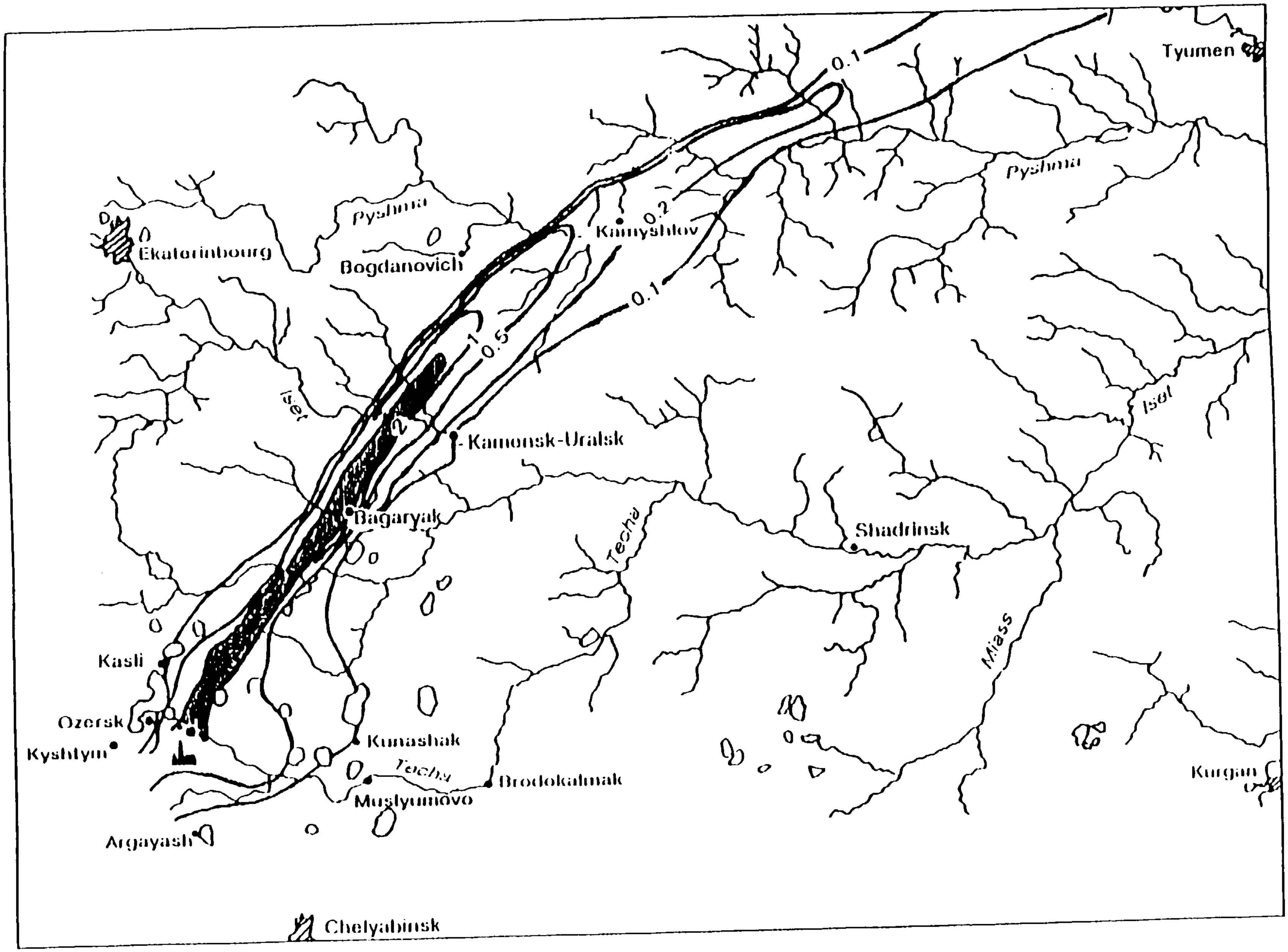

Fig. 3.

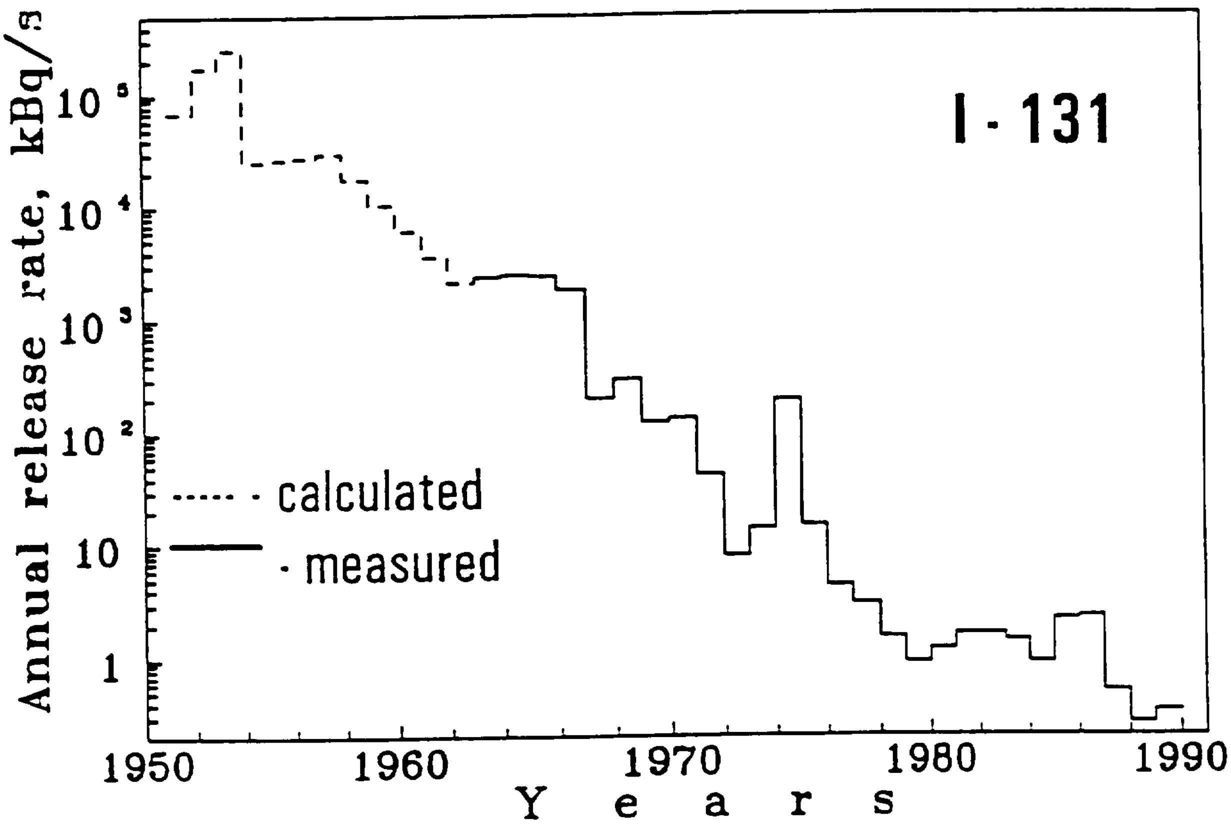

Fig. 4. Releases into the atmosphere (data of E.Drozhko et al.).

Systematic measurements of radioactive contamination in and near the Techa River started in the summer of 1951. The contamination of the river water, bottom sediments, flood-plain soils, vegetation, fish, milk, and other food stuffs, and external gamma-exposure rates were measured. In 1957 the monitoring was expanded to include the area covered by the EURT. Systematic control of the MIA operating releases and measurements of ^{131}I concentration in food stuffs started only in 1962. For the town of Ozersk (which was the living place of the workers at the MIA and which was mostly affected by gaseous aerosol releases) regular measurements of ^{90}Sr and ^{137}Cs started in 1956, and the monitoring of exposure rates began in 1964. The results of all these measurements are kept in archives at the MIA and the URCRM, mainly on paper media (maps, working notebooks, technical reports, etc.). Some of them are still classified.

The population of the contaminated territories was exposed to external and chronic internal irradiation. Medical checkups of people living in the Techa Riverside communities had been started by 1951. In addition to medical examinations, individual data on the conditions of contact with the contaminated river (the distance of the house from the water's edge, the source of drinking water, fishing, etc.) were collected. Also, radiometric measurements of bioassay and autopsy samples were performed. Medical checkups of the population of the most contaminated area of the EURT were started in autumn 1957. Later, a registry numbering 90,000 subjects in the accidentally exposed population (the residents of the Techa Riverside communities and the residents of the area covered by the EURT) was established at the URCRM. All places and terms of residence inside the contaminated area were collected for the members of this registry for the purposes of individual-dose reconstruction. Also, extensive measurements of ^{90}Sr content in teeth were performed beginning in 1960 and in forehead bone beginning in 1976; whole-body counting for ^{90}Sr has been performed since 1974. Now the main part of this information is contained in a computerized data base at the URCRM. The registry for the population exposed as a result of the operational releases at the MIA is not established yet, but this work has been started at Branch 1 of the Moscow Biophysics Institute (FIB-1). Also, the results of measurements of ^{90}Sr and Pu in samples collected at autopsy for the residents of Ozersk and nearby territories number several thousand and are kept in the archives of the MIA and the FIB-1. So, three cohorts of exposed populations can be selected based on the nature of exposure and according to the history of follow-up and available data. These are the Techa River Cohort, the EURT Cohort and the Ozersk Cohort (not yet established). Some efforts addressed to dose reconstruction and risk assessment for the first two cohorts were taken in the URCRM and the results have been published in the open literature.

Techa River Cohort

The Techa River cohort (TRC) is important, because some of its members have received relatively high doses and a significantly increased risk of leukemia in this group has been observed (Kossenko and Degteva 1994). There is some evidence that solid tumors may also be in excess. The residents of the villages along the Techa were exposed to both external irradiation (from contaminated river water, sediments, flood-plain soils) and internal irradiation due to ingestion of radionuclides with drinking water and diet. The original dose-reconstruction methods for the TRC have been described in detail elsewhere (Degteva et al. 1994).

The absorbed doses due to external exposure were estimated on the basis of systematic measurements of gamma-exposure rate along the banks of the river and the typical life-style patterns of the inhabitants of the riverside villages. This approach has given the average annual absorbed doses from external sources for different age groups in each village. The data available do not provide information on the variations in individual-dose levels among the residents of a village. Instead the average value for specified age groups living in a specified settlement has been assigned to each member of cohort. Also, it was assumed that the total dose due to external exposure was accumulated during the period 1950–1955. This approach has a number of limitations that result in both random and systematic errors in individual-dose estimates.

The main contributor to the internal exposure among the radionuclides released into the Techa River was ^{90}Sr, which is accumulated in bone tissues and retained there for many years. In vivo beta-ray measurements on teeth, which have been performed since 1960, and a large number of ^{90}Sr measurements in whole body have been the basis of internal dose reconstruction (Kozheurov 1994). The reconstruction of internal dose depends on both estimates of the intake and models for metabolism of ingested radionuclides. Beta-ray measurements on teeth are utilized to deduce the annual levels of intake of ^{90}Sr in the different villages in the different age cohorts. The ingestion of other radionuclides (^{89}Sr and ^{137}Cs predominantly) occurred mostly with water in the first three years of the river contamination. The intake rates of ^{89}Sr and ^{137}Cs were therefore derived from estimates of the ingestion of ^{90}Sr scaled in terms of the radionuclide composition of the river water. These data were used to estimate age-dependent intake rates for all Techa River villages (Kozheurov and Degteva 1994). Calculation of absorbed doses in tissues due to radionuclide incorporation is based on age-dependent metabolic and dosimetric models and the corresponding ingestion rates. A large number of measurements of ^{90}Sr-body content made with a whole-body counter (WBC) has been utilized for the validation of the metabolic model for strontium retention in human bone (Degteva and Kozheurov 1994). Absorbed doses in red bone marrow (RBM) and bone surfaces (BS) have been calculated for all age cohorts. The absorbed doses in RBM and BS are substantially higher than those in other tissues, because of ^{90}Sr was the main radionuclide of interest and strontium is a bone-seeking element. The upper limit of total doses absorbed in RBM is estimated as about 3 Gy.

EURT Cohort

Initially a sub-cohort of the population evacuated from the most contaminated territories of the EURT numbering 7,854 people was established at the URCRM (Kostyuchenko and Krestinina 1994). Average-dose estimates for the residents of different villages were taken from two independent sources of information (Romanov 1990 et al.; Skryabin et al. 1985), which gave different assessments. Dose calculations were undertaken on the basis of the levels of radionuclide contamination of soil (a significant non-uniformity of contamination being noted) and known isotopic composition of local fall-out. The range of effective doses for this part of the population was from 40 to 500 mSv. No statistically significant changes in cancer mortality as compared to the control group have been reported for this sub-cohort (Kostyuchenko and Krestinina 1994). Analogous results for another sub-cohort of 8,000 non-evacuated EURT residents who received effective doses from 50 to 66 mSv were reported in 1994 in Ekaterinburg

(Krestinina et al. 1994). The formation of the EURT Cohort is not finished yet, and only tentative dose assessments have been done.

Ozersk Cohort

The most complete information on methods and on evaluation of uncertainties in reconstruction of doses from radiation exposure for populations living near nuclear plants is in the works of American specialists, who carried out work on the reconstruction of doses due to the operation of the Hanford plants. In Russia attempts have been made to estimate similar radiation doses due to gaseous and aerosol radioactive releases from the MIA. These attempts show that the highest levels of radiation exposure might have been in the early years of the operation of the MIA. The main dose-forming radionuclide at that time was ^{131}I (as mentioned above, it is estimated that about 560,000 Ci were released) entering the body with food. Subsequently, the improvement of the system of filtration led to considerable improvement of the radiation situation around the enterprise, including that in Ozersk. However, the contamination of the territory of the town with the releases of the early years and secondary elevation of long-lived radionuclides with the wind remain the main source of man-made radiation exposure for the population of Ozersk up to now.

4. PRELIMINARY STUDIES

The results of preliminary studies and the databases available to support major dose-reconstruction efforts are described in detail in Appendix A.

5. RESEARCH DESIGN AND METHODS

All Cohorts

The research design and the methods to be used to support the dose-reconstruction efforts for these the Techa River, EURT, and Ozersk Cohorts are described in detail in Appendix A. Material provided in the appendix includes an introduction that describes the releases that have occurred and the cohorts of interest. The measurements that are available to support a dose reconstruction are also described. On the basis of the information now available and the information considered likely to be available over the next few years, a complete strategy is laid out to derive the required individual estimates of dose for the cohorts of interest. To back up this strategy a project organization is developed that lays out the individual tasks necessary to accomplish the work. In every stage of the proposed work the strategy is to make maximum use of the highest level of information (measurements) available; thus, it is a hybrid approach with an attempt to minimize modeling in favor of measurements where possible. Finally a master schedule is laid out for the dose-reconstruction work for each of the three cohorts of interest. First priority is given to the Techa River Cohort, second priority to the East Urals Radioactive Trace Cohort, and third priority to the Ozersk Cohort. There is some question whether the Ozersk Cohort will be included in any further studies, and we have outlined as the first task the conduct of an epidemiologic feasibility study. That is, we propose to perform or adopt an initial approximate calculation of dose in order to determine if the doses are large enough and there is a sufficient number of exposed people to provide enough power for a useful epidemiologic study. Also included are a management plan arranged by task and an overall timetable and milestone chart for the projected dose-reconstruction efforts.

Ozersk Cohort

Plans for the dose-reconstruction effort for the Ozersk Cohort are also included in Appendix A.

During the proposed pilot-scale activity for the Ozersk Cohort it is proposed to work extensively with the existing archival materials at the MIA in order to catalog them and classify them according to their information content and usefulness. During this process it is proposed to develop statistical methods of processing information and methods of modeling the behavior of nuclides in the environment of concern to the Ozersk Cohort. This phase of research would focus on the atmospheric releases of ^{131}I.

6. QUALITY ASSURANCE/QUALITY CONTROL

One of the first tasks of the project will be to develop a detailed quality assurance/quality control plan. Such activities have been discussed extensively during the preparation of the material in Appendix A, but the plan has not yet been developed explicitly. One reason for including the University of Utah in this proposed study is that much of the actual data planned to be used to support the dose-reconstruction study relates to electron paramagnetic resonance analysis of teeth samples and to the thermoluminescence analysis of environmental materials. Dr. Haskell is recognized as an international expert in this field, and he will be expected to ensure that all scientists in these studies have participated in international intercalibration projects.

Another primary aspect of the overall project is the recalibration of the URCRM whole-body bremsstrahlung counter, which is another critical component of the study in terms of providing primary data for the dose-reconstruction study. The development of a new physical phantom is already part of the funded activities that support this study, and computer phantoms will also be developed for assistance in the recalibration of this important instrument. (The instrument was calibrated initially with phantoms made of wax and cadavers, which have long since deteriorated.)

All databases to be used in the project will subjected to quality-assurance tests and to standard methods of verification. As is standard practice in Russia, all procedures used in such important projects are submitted to a special authority on metrology for approval before they can be officially used.

Finally, the European Commission and Institutes from Germany and Japan are participating in various studies that overlap with this project. Most of their planned activities are rather limited in terms of actually carrying out dose reconstructions. Rather, they focus on validation and verification of the data that have already been developed by the Russian scientists working on these projects for many years. Thus, our complete quality assurance/control efforts will be greatly aided by extensive international intercalibration and validation studies.

7. COLLABORATORS/COLLABORATING INSTITUTIONS

The names of the collaborating institutions and the lead scientists are indicated in the management plan that is included in Appendix A. The only exception is Dr. Edwin Haskell of the University of Utah. His role in the proposed project is described in Item 6 above.

The Curricula Vitae of the primary participants are included in Appendix B.

8. HUMAN-SUBJECTS CONSIDERATION

The subjects for whom we propose to conduct an individual-dose reconstruction will be enrolled in this study based upon presumptive evidence of their exposure (or lack of exposure for controls) due to their residence history and other factors. In all cases these cohorts have already been reasonably well defined by the companion epidemiologic studies.

For purposes of dose reconstruction much of the valuable data has already been collected by the Russian investigators over many years of work. In addition, persons selected for individual-dose reconstruction may be invited to return to the URCRM for measurements in the whole-body counter. Efforts will be made to collect teeth for analysis by electron paramagnetic resonance, but such collections will be made only if teeth are being removed for purposes of dental health. Some individuals will probably be asked to provide 5–10 cc of venous blood that can be used for biological dosimetry.

Any techniques of measurements undertaken for the subjects that are unique or additional for this project will be performed under the guidance of appropriate Institutional Review Boards. Such Boards will be those in the Chelyabinsk Oblast or elsewhere in Russia and those appropriate for any institution in the USA that may receive samples.

Confidentiality of all information will be assured by restricting access to identifying personal information to one institution in Russia. Any information of an individual nature derived during the course of this project will be made available to the affected individual.

9. ITEMIZED BUDGET

This information is provided in Appendix C.

The money indicted in Appendix C for the URCRM includes money that would be transferred to the Institute of Metal Physics for the conduct of electron paramagnetic resonance analysis of teeth and/or bone samples for a direct measurement of dose. Additional money will likely be transferred to the Institute of Marine Transport Hygiene to provide additional assistance in the development of computer phantoms for the recalibration of the URCRM bremsstrahlung counter.

In addition to the direct support requested above other resources are anticipated to contribute to this study. First of all, we anticipate that additional funding will be provided to the URCRM, the MIA, the Institute of Marine Transport Hygiene, and Branch No. 1 of the Institute of Biophysics (FIB-1) by the Russian Ministries of Health, Atomic Energy, and Emergency Situations. We presume that the magnitude of such contributions will be negotiated by the members of the JCCRER or its Executive Committee during the next few months. The FIB-1 will also receive money from the U.S. side for other projects, and we plan that their staff members will thus be available for consultation on this project. Also, contributions to this study will be made by personnel of the Federal Nuclear Center (Chelyabinsk-70) who have a funded study (from the International Science and Technology Center) with elements that are closely aligned with the study proposed here. Finally, we expect that the U.S. National Cancer Institute and the Centers for Disease Control and Prevention will contribute a fraction of the time of their federally employed dosimetrists to work on this project. And, while arrangements are not finalized, we know that relevant work is being funded or considered for funding by sources in Japan and in western Europe. In general the work proposed above has not included any work that we believe has a high probability of being funded by other agencies or countries.

10. PUBLIC INVOLVEMENT

The U.S. Department of Energy, other involved agencies, and other involved persons have expressed a strong desire to have a well thought out plan for public involvement in the dose-reconstruction process. While no such plan has yet been explicitly formulated, our proposal is to join initially with other public-outreach programs in the Chelyabinsk Oblast that are already in process. The URCRM itself is largely a public-outreach program, as one of its primary missions is to engage the affected public through special medical care and dose determination through measurements, such as whole body counting, of the affected population. In addition, the local representative of the Ministry of Emergency Situations has a public-outreach program in place, and we anticipate that the magnitude of this program will increase during this project. Finally, we have proposed that the local government of the Chelyabinsk Oblast be one of the primary foci of any public-involvement process. Some initial discussions with the Lieutenant Governor have already been conducted, and it is quite clear that they are very interested in participating in any public-involvement program. As this project is a government to government project, we believe that the local government and local representatives of the involved Ministries must have the primary responsibility for a public-involvement program. We do not at this time propose any direct involvement of U.S. participants with non-governmental environmental groups.

It has been made quite clear to us that our Russian partners are very apprehensive of any attempts of the U.S. side to dictate the terms of public involvement. They have already had several unfortunate experiences with persons from the U.S. and other countries who have engaged the public directly.

We hope that this sensitive political issue will be discussed extensively during future meetings of the JCCRER and its Executive Committee.

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APPENDIX A:

DETAILED RESEARCH DESIGN, METHODS, AND MANAGEMENT PLAN

The following material is taken directly from the Final Report for Pilot-Scale Project 1.1 (Degteva et al. 1996). The original page numbers have been preserved.

Original page number 40 has been deleted, as it contained a figure pertaining to a prior section of the Final Report.

FINAL REPORT FOR MILESTONE 1.1.3 "PREPARE A REPORT THAT WILL INCLUDE THE METHODOLOGY FOR AND AN ASSESSMENT OF THE FEASIBILITY OF RECONSTRUCTING THE DOSES FOR PERSONS IN THE COHORT CONSIDERED IN PROJECT 1.2"

1. Introduction

The reconstruction of radiation exposures to people living in the vicinity of the Mayak facility is potentially very complex. A graphical depiction of the primary sources of release and the resulting primary ways in which the public was exposed from these releases is shown in Fig. 13.

During the first decade of operation of the Mayak facility, gaseous and particulate radionuclides were released to the atmosphere in large quantities. Of potential public concern is the release of ^{239}Pu. Elevated levels of plutonium have been measured in the people living around the Mayak facility to distances of up to 100 km (Suslova et al. 1995). This plutonium would have been released through routine ventilation of the processing facility. The main pathway of exposure to plutonium is inhalation, both during passage of the released plumes and afterwards as a result of resuspension.

In a manner analogous to that at the Hanford Site in the United States (TSP 1994), ^{131}I was also released to the atmosphere from routine processing operations (Khokhryakov et al. 1995). Iodine-131 is a reactive gas that deposits readily on vegetation and can be ingested by grazing cattle and transferred to milk. Production records and meteorological data are available for estimating the releases of ^{131}I and plutonium and their subsequent environmental distribution.

Other radionuclides were also emitted into the air during facility operations. Screening studies indicate that the doses resulting from these releases are relatively small. Documentation of the magnitudes of these releases will be prepared. It is likely that the primary exposure route for these other radionuclides will be external exposure.

Non-routine releases of radionuclides to the atmosphere also occurred. A small pond used to receive contaminated liquids, Lake Karachai, dried around the banks and provided a source for windblown resuspension during brief periods when the wind was high. About 600 Ci of longer-lived fission products were released to the air in this manner (Romanov 1995). The main exposure pathway is external exposure from materials deposited on the ground.

In 1957, a chemical explosion in a high-level waste tank (the so-called Kyshtym Accident) resulted in the release of about 2 million curies to the atmosphere, primarily ^{144}Ce, ^{95}Zr, ^{95}Nb and ^{90}Sr, deposited in a footprint called the East Urals Radioactive Trace (EURT) covering several thousand square kilometers. This area was extensively monitored for recovery efforts. Following the immediate deposition, the long-term pathways leading to the greatest exposure have been external irradiation and ingestion of ^{90}Sr (Romanov 1995).

Between 1949 and 1956, liquid releases from the radiochemical plant and unmonitored overflow from cooling of the waste tanks resulted in release of about 3 million curies of mixed fission products to the Techa River, which traverses the Mayak site. Eventually, this resulted in external and ingestion exposures of 30,000 people living downstream along the river. Because of the long-term nature of the exposures, the primary radionuclide of concern from ingestion is ^{90}Sr. Other shorter-lived fission products contributed to the external and internal dose.

Joint collaborations with epidemiologists working in Project 1.2 have identified three cohorts of people to be studied. In order of priority, these are 1) the people living along the banks of the Techa River, primarily exposed to the liquid effluents (the Techa River cohort), 2) the people exposed to the deposition from the East Urals Radioactive Trace (the EURT cohort), and 3) the residents of the city of Ozersk (Chelyabinsk-65), primarily exposed to the atmospheric releases of iodine, plutonium, and noble gases from routine Mayak operations (the Ozersk cohort). An epidemiological study of the Ozersk cohort is not yet certain; a pilot study to determine the possible statistical power of an epidemiology study is first proposed.

2. Dose Reconstruction Process

Radiation dose reconstructions are generally structured on a paradigm of release-transport-deposition-uptake/exposure-dose. The initial components are actually the most technically difficult; the individual dose calculation requires individual-specific information that must be obtained from the individual involved. Radioactive materials released to the environment generally are transported, deposited, and taken up in plants and animals in ways that are independent of individual humans. Individuals are exposed to time-varying "fields" of radiation and radioactive materials. Therefore, it is possible to reconstruct the time histories of the radiation fields and radionuclide concentrations without considering the activities of specific individuals. Once the time histories of the radionuclide fields throughout an area are known, it is possible to "introduce" the people into them and estimate the human's uptakes and resultant doses.

For many of the most significant exposures considered for these cohorts, historical information on the processes and releases is limited. However, measurements of radionuclides in specific people (^{90}Sr in bones or teeth, etc.) are available and may be used to estimate individual doses and, by implication, the fields to which others were exposed. Therefore, the dose reconstruction process planned is based extensively on measurements of radionuclide burden or exposure in humans, and the traditional paradigm is only used as a backup when other approaches have been exhausted. The types of information available are summarized in Table 5. Uses of each type of information is discussed below. The following discussion is structured on the basis of the primary cohorts and exposure pathways.

2.1 Techa River Residents - Internal Dose

The internal dose reconstruction approach for Techa River residents is described in Section 2.1.1. The tasks that derive from this approach are summarized in Section 2.1.2.

2.1.1 Techa Cohort Internal Dose Reconstruction Hierarchy

The hierarchy of information required for calculating internal radiation doses to people who lived along the Techa River during and after the largest releases is shown in Fig. 20. Internal dose is related to the time integral of the body burden. Information related to time is readily accessible through birthdates and residence histories. As shown in Table 5, a large number of individuals have had at least one whole body count; many have had several. These individual records are the preferred primary data for individual dose reconstruction. A smaller number of individual autopsy data are available; these are also preferred starting points. The last resort for estimating body burden histories for individuals is via analogy to family members or residents of the same location - if individual measurements are not available, it is preferable to estimate them via individual intake and metabolic models.

A sufficient number of sequential whole body counts for single individuals have been assembled so that detailed models of radionuclide uptake and retention can be prepared. Default metabolic models from the ICRP may also be employed.

Table 5. The types of information available for individual dose reconstruction

Cohort	Group/Number	Dominant Pathways	Type of data	Available Data	Number Available	Comments
A. Techa River Residents	A1. 4,500 subjects who lived in upper reaches in 1949-1952 and were evacuated later	External	Environmental	Historically measured dose rates Quartz TLD	250 5 locations	1951 - 1956 In Metlino village
			Individual	EPR	5	Requires spectrometer
		Internal (water, milk, fish)	Environmental	Historically measured food stuffs	~100	1951 - 1956. Non computerized
			Individual	Whole body counts Tooth counts Sr-90 autopsy data Excreta counts Source of drinking water (well or river)	1,500 2,000 60 Many 2,500	Sr-90 and Cs-137 since 1974 Sr-90 since 1960 1951 - 1972 Mainly gross beta, non computerized Non computerized, could be extended via family data
		Both external and internal	Environmental	Historically measured media (water, sediments, soils)	3,500	1951-1956, mainly gross beta
			Individual	Residence history	4,500	Including house location for some of subjects
	A2. 22,000 subjects who lived in lower reaches in 1949-1952	External	Environmental	Historically measured dose rates Quartz TLD	>120 4 locations	1951-1956; later: non computerized In Muslyumovo village
			Individual	EPR	22	Requires spectrometer
		Internal (water, milk, fish)	Environmental	Historically measured food stuffs	~1000	Non computerized
			Individual	Whole body counts Tooth counts Sr-90 autopsy data Excreta counts Source of drinking water (well/river)	7,000 8,500 100 Many 8,000	Sr-90 and Cs-137 since 1974 Sr-90 since 1960 1955 - 1972 Mainly gross beta, non computerized Non computerized, could be extended via family data
		Both external and internal	Environmental	Historically measured media (water, sediments, soils)	7,000	Gross beta, Sr-90 and Cs-137 since 1968
			Individual	Residence history	22,000	Including house location for some of subjects

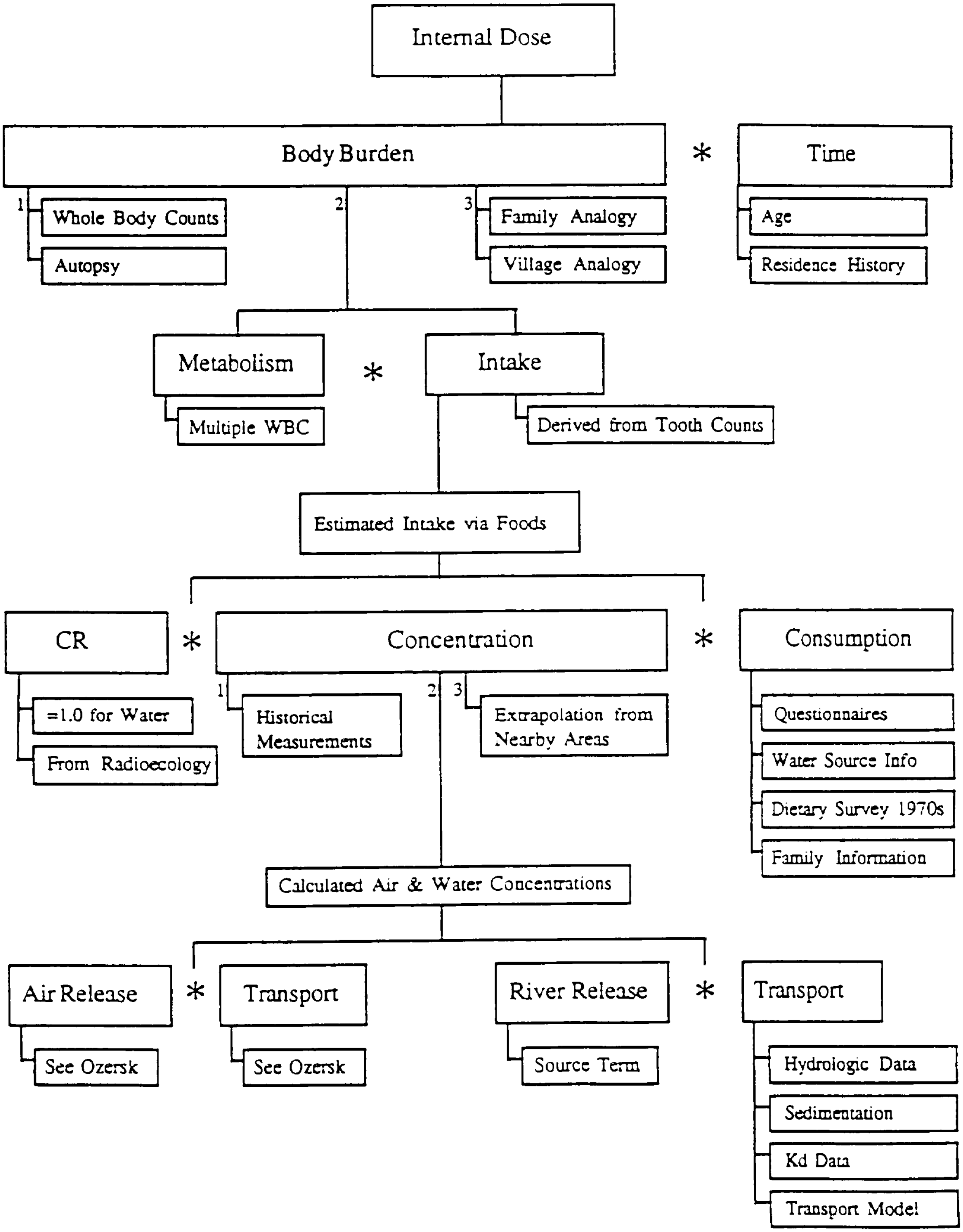
Table 5. (Continued)

Cohort	Group/Number	Dominant Pathways	Type of data	Available Data	Number Available	Comments
A. Techa River Residents	A3. 7,800 "late entrants" who moved in after 1952	External	Environmental	Historically measured dose rates Quartz TLD	120 4 locations	The same as for Cohort A2 but could be used since the date of entrance
			Individual	EPR	7	Requires spectrometer
		Internal (water, milk, fish)	Environmental	Historically measured food stuffs	~1000	Non computerized
			Individual	Whole body counts Tooth counts Sr-90 autopsy data Source of drinking water (well/river)	4,000 4,000 20 2,000	Sr-90 and Cs-137 since 1974 Sr-90 since 1960 1955 - 1972 Non computerized, could be extended via family data
		Both external and internal	Environmental	Historically measured media (water, sediments, soils)	7,000	The same as for Cohort A2 but could be used since the date of entrance
			Individual	Residence history	7,800	Including house location for some of subjects
B. EURT Residents	B1. 1,200 subjects evacuated early	External	Environmental	Historically measured dose rates	12	3 locations within 1 month after accident
			Individual	EPR	0	Requires spectrometer
		Internal (inhalation, bread, milk)	Environmental	Dietary investigations	?	Non computerized
			Individual	Whole body counts Tooth counts Sr-90 autopsy data	35 35 1	Sr-90 and Cs-137 Sr-90 1964
		Both external and internal	Environmental	Historically measured media	?	Non computerized
			Individual	Evacuation dates	1,200	Residence histories after evacuation non computerized
	B2. 14,000 subjects either evacuated late or not evacuated	External	Environmental	Historically measured dose rates	Many	Non computerized
			Individual	EPR	3	Requires spectrometer
		Internal (bread, milk)	Environmental	Dietary investigations	Many	Non computerized
			Individual	Whole body counts Tooth counts Excreta counts Sr-90 autopsy data	150 150 Many 45	Sr-90 and Cs-137 Sr-90 Gross beta, non computerized 1958 - 1972
		Both external and internal	Environmental	Historically measured media	Many	Non computerized
			Individual	Residence history	14,000	Non computerized

Table 5. (Continued)

Cohort	Group/Number	Dominant Pathways	Type of data	Available Data	Number Available	Comments
C. Ozersk Residents	? (not established)	External	Environmental	Historically measured dose rates	?	Since 1964, non computerized
			Individual	EPR	9	Requires spectrometer
		Internal (milk, inhalation)	Environmental	Historically measured food stuffs	?	Sr-90 and Cs-137 since 1956, I-131 in milk in 1962-1964
				Radionuclide measurements in air	?	Beginning in 1960s
			Individual	Cs-137 whole body counts	700	Since 1970, non computerized
				Sr-90 autopsy data	1000	Since 1963, non computerized
				Pu and Am autopsy data	450	Since 1975, non computerized
		Both external and internal	Environmental	Approximate Source Term	?	Requires Mayak participation
				Climatological meteorology	?	Use of better information requires better source term
			Individual	Residence history	?	Could be restored from Ozersk archives information

Figure 20. Information Hierarchy for Estimating Internal Dose to Techa River Residents



There were a very large number of potential routes of ingestion of radionuclides. Drinking water, eating fish, and eating various contaminated garden crops and animal products could all lead to intake of radionuclides. A technique has been developed based on in-vivo measurements of ^{90}Sr in teeth that provides a reliable estimate of direct intake (Kozheurov and Degteva 1994). For individuals for whom examinations of radionuclide content in teeth have been made, this technique can be used to calculate ingestion rates of radionuclides. Also, as a backup for those individuals for whom tooth counts are not available, intake estimates for similar categories of people may be approximated using this technique. Alternatively, intakes may be approximated using food consumption rates and radionuclide concentrations in foods.

Consumption rates vary by age, sex, ethnicity, and perhaps by village. An extensive set of individual lifestyle and dietary questionnaires were administered to Techa River residents. A separate data set related to sources of drinking water (river or well) is also available in clinic outpatient records; this information is not yet available in digital form. In the 1970s, dietary surveys were made of people living in the EURT areas - this data could provide some default information if individual dietary preferences are not available. As a default, family or village food ingestion rates can be compiled.

Historically measured radionuclide concentrations in some selected environmental media (primarily river water and sediments) are available. However, it is likely that reconstruction of food contamination levels will be required. This can be done using extrapolation in a few instances, but generally concentrations must be calculated from common radioecological transfer factors and estimated river water concentrations. River water concentration must be estimated from released amounts and a river water transport model. The released amounts (source term) must be estimated from Mayak operating records and process descriptions.

Members of the Techa River cohort were primarily exposed to the effluents in the river, however, the atmospheric releases also affected this group - particularly those on the upper Techa near the Mayak facilities. The doses resulting from these atmospheric releases will be added to the doses calculated for this cohort according to the techniques described in Section 2.6 for the Ozersk cohort.

2.1.2 Techa River Cohort Internal Dose Activity Descriptions

The following activities are necessary to complete the full dose reconstruction illustrated in Fig. 20.

Evaluation of Bioassay Data This subtask will evaluate available whole body count data, excreta count data and autopsy data. This will provide body burden/intake estimates for individuals for whom measurements exist. This task will also assemble a database of whole body count derived body burdens for each family or village to be used as surrogates in case other approaches fail for unmeasured individuals.

Metabolic Models This subtask will use available sequential whole body count data to update radionuclide retention functions. This metabolic model would then be used to help evaluate all whole body counts to provide the integral exposures.

Tooth Count Analysis This subtask will extend the technique of Kozheurov and Degteva (1994) for dietary intake evaluation based on in vivo measurements of ^{90}Sr in teeth beyond the village of Muslymovo, where it was developed, to other sites along the Techa River.

Establish Food Consumption Rates This subtask will develop individual dietary intakes of various foods and water as functions of age, sex, ethnicity, and location. The efforts will use individual dietary information, results of local surveys, and information on the sources of drinking water.

Analysis of Historical and Current Monitoring Data This subtask will compile and evaluate available data on radionuclide concentrations in water, sediment, soil, and food. This information will serve as input to the radioecology and river transport subtasks.

Radioecology This subtask will review available data to determine the most appropriate transfer factors for radionuclides in fish, milk, and food crops. Sources of data may include site-specific measurements as well as generic sources such as the International Union of Radioecologists. This information will be used to develop estimates of radionuclide content in food crops.

Techa River Source Term Development This subtask will prepare estimates of the time history of radionuclide release to the Techa River. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task will develop estimated release fractions and prepare release estimates for use in transport modeling. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates. It is anticipated that staff from the Mayak Industrial Association will be key participants in this task.

Techa River Transport Modeling This subtask will accumulate data describing the historical Techa River hydrologic data, sediment loading, and dam construction history. This will be used as input to a numerical transport model to simulate the flow and contaminant loading of the Techa River from the Mayak facility to its confluence with the Iset River. The model will provide concentrations of radionuclides in water and sediment at specified locations along the river.

Techa River Cohort Internal Dose Estimation This task will provide management coordination and integration for the other subtasks involved with the Techa cohort. This task will assimilate the data and information prepared by the other tasks and make individual internal dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

2.2 Techa River Residents - External Dose

The external dose reconstruction approach for Techa River residents is described in Section 2.2.1. The tasks that derive from this approach are summarized in Section 2.2.2.

2.2.1 Techa Cohort External Dose Reconstruction Hierarchy

The hierarchy of information required for calculating external radiation doses to people who lived along the Techa River during and after the largest releases is shown in Fig. 21. Measurements of tooth samples made with Electron Paramagnetic Resonance techniques have been shown to give very reliable and accurate indications of absorbed dose. This would be the highest priority technique for determining external exposure; however, from Table 5, it is apparent that very few individuals have been measured to date. A continuation of these studies is proposed. In addition, there is interest to evaluate whether biodosimetric techniques (e.g., florescent in-situ hybridization, T-Cell receptor, and others) can provide reliable estimates of external dose. Studies to date on these techniques have been inconclusive (Akleyev 1995), and pilot efforts to continue the research are proposed because the potential return on the investment is very high.

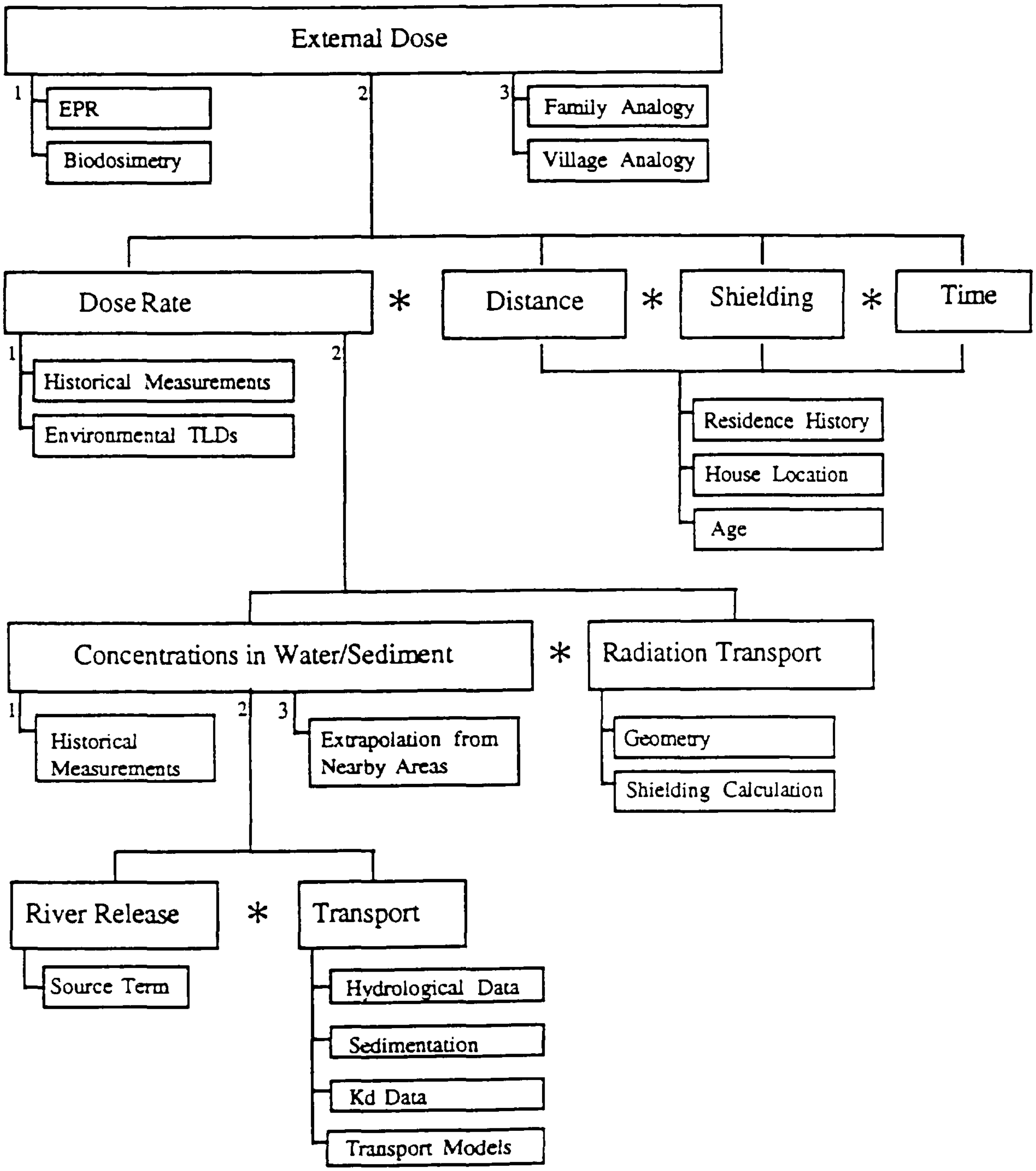
External dose is related to the time integral of the dose rate field to which individuals were exposed. Information related to time is readily accessible through birthdates and residence histories.

Some historical measurements of radiation dose rate were made in the vicinity of the Techa River. Most of these were made after the period of greatest release. Current environmental measurements can provide information about recent exposures; however, they lack any details of the contribution of short-lived radionuclides. A promising source of external dose rate data is the use of environmental thermoluminescent materials. This technique has been shown to be effective (Bougrov 1995), but as is indicated in Table 5, its use to date has been limited. Thus, it will be necessary to also approach the problem by investigating classical radiation shielding calculations.

Historically measured radionuclide concentrations in some selected environmental media (primarily river water and sediments) are available. However, it is likely that reconstruction of contamination levels will be required. This can be done using extrapolation in a few instances, but generally, concentrations must be calculated from released amounts and a river water transport model. The released amounts (source term) must be estimated from Mayak operating records and process descriptions.

Members of the Techa River cohort were primarily exposed to the effluents in the river, however, the atmospheric releases also effected this group - particularly those on the upper Techa near the Mayak facilities. The doses resulting from these atmospheric releases will be added to the doses calculated for this cohort according to the techniques described in Section 2.5 for the Ozersk cohort.

Figure 21. Information Hierarchy for Estimating External Dose to Techa River Residents



2.2.2 Techa River Cohort External Dose Activity Descriptions

The following activities are necessary to complete the dose reconstruction process illustrated in Fig. 21.

Electron Paramagnetic Resonance (EPR) This subtask will perform additional measurements as tooth samples become available through routine dental work and postmortems (no active recruitment of samples from exposed individuals is planned). These measurements will be used as the basis for external dose for the affected individuals and also placed into a database from which statistical regressions based on age and residence can be made to provide a source of analog information for persons without direct measurements. It is anticipated that this subtask would be performed by staff of the Metal Physics Institute in Ekaterinbourg. Procurement of an EPR spectrometer will simplify and greatly increase the number of samples that could be analyzed annually.

Environmental Thermoluminescent Dosimetry (TLD) This subtask will perform additional measurements in environmental samples collected at predetermined locations along the Techa River. A detailed sampling plan will be developed to optimize the number of samples required. The dose rates evaluated will be used to prepare a regression of dose rate for various distances away from the river at locations downstream of the release point. This will also serve to validate the radiation transport and shielding calculations.

Biodosimetry Pilot Study A feasibility study will be undertaken to evaluate the accuracy and reliability of measurements made with a suite of biodosimetric techniques, including fluorescent in-situ hybridization, T-cell receptor, and other techniques. If any of the techniques compare well with measurements made by other methods (EPR, etc.), further requests will be made to the JCCRER Executive Committee to incorporate the techniques into the ongoing dose reconstruction efforts.

Analysis of Historical and Current Monitoring Data This subtask will compile and evaluate available data on radionuclide concentrations in water and sediment. This information will serve as input to the river transport and radiation transport/ shielding subtasks.

Techa River Source Term Development This subtask will prepare estimates of the time history of radionuclide release to the Techa River. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task will develop estimated release fractions and prepare release estimates for use in transport modeling. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates. It is anticipated that staff from the Mayak Industrial Association will be key participants in this task.

Techa River Transport Modeling This subtask will accumulate data describing the historical Techa River hydrologic data, sediment loading, and dam construction history. This will be used as input to a numerical transport model to simulate the flow and contaminant loading of the Techa River from the Mayak facility to its confluence with the Iset River. The model will provide concentrations of radionuclides in water and sediment at specified locations along the river.

Radiation Transport/Shielding Calculations This subtask will extend available measurements (from TLD and conventional sources) to provide dose rates as a function of location away from the Techa River. Inputs to the modeling will generally come from the Techa River source term and transport modeling activities.

Techa River Cohort External Dose Estimation This task will provide management coordination and integration for the other subtasks involved with the Techa cohort. This task will assimilate the data and information prepared by the other tasks and make individual external dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

2.3 East Urals Radioactive Trace (EURT)—External Dose

The external dose reconstruction approach for residents exposed to the deposition forming the East Urals Radioactive Trace (EURT; also known as the "Kyshtym explosion") is described in Section 2.3.1. The tasks that derive from this approach are summarized in Section 2.3.2.

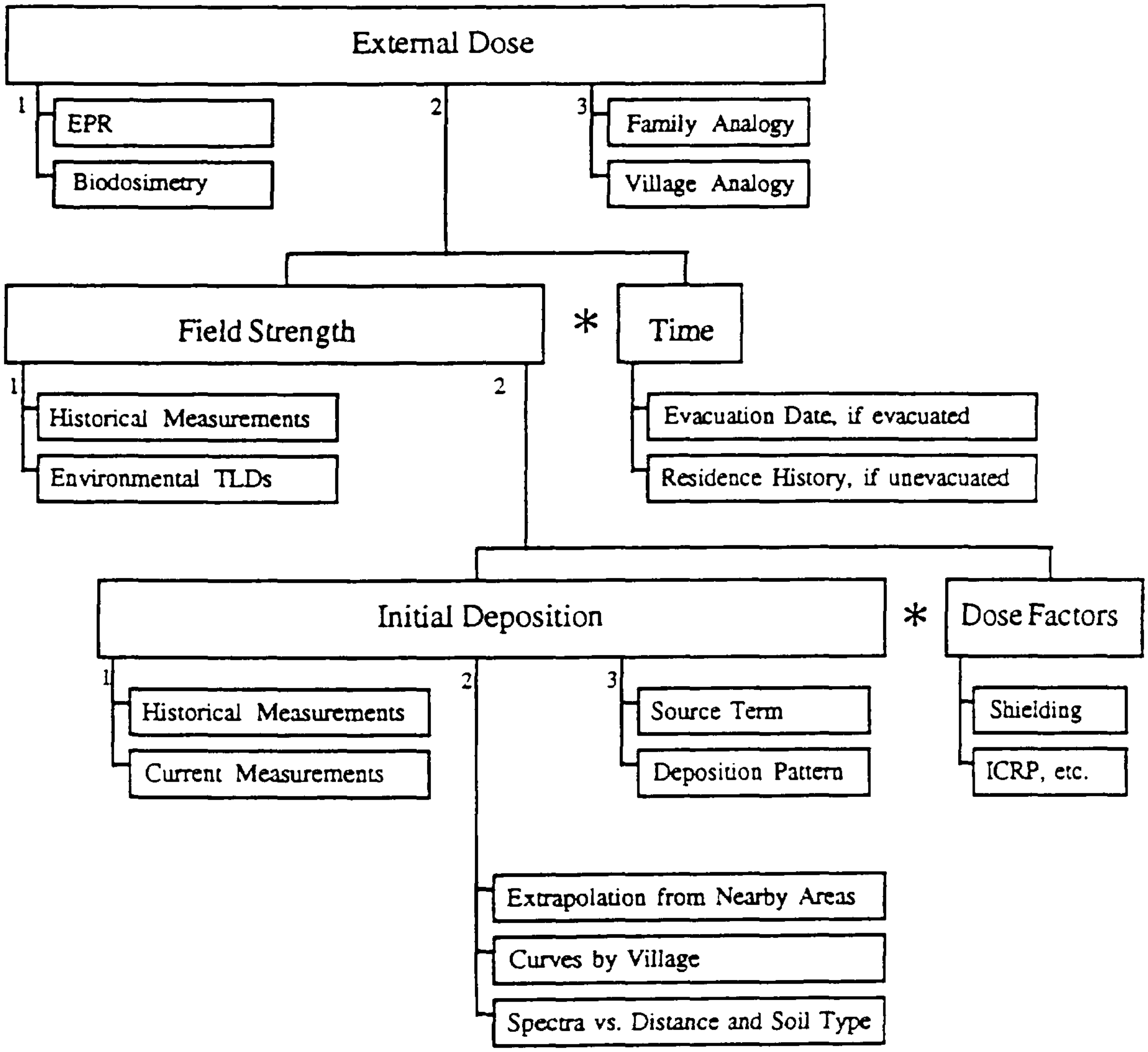
2.3.1 EURT External Dose Reconstruction Hierarchy

Residents of the area impacted by the EURT deposition may be divided into two groups (see Table 5) - those evacuated within the first days immediately following the release and those who were not evacuated. The general approach to external dose reconstruction is the same for both groups.

The hierarchy of information required for calculating external radiation doses to people who lived in the area effected by the EURT release is shown in Fig. 22. Measurements of tooth samples made with Electron Paramagnetic Resonance techniques have been shown to give very reliable and accurate indications of absorbed dose. This would be the highest priority technique for determining external exposure; however, from Table 5 it is apparent that very few individuals have been measured to date. A continuation of these studies is proposed. In addition, there is interest to evaluate whether biodosimetric techniques (e.g., florescent in-situ hybridization, T-Cell receptor, and others) can provide reliable estimates of external dose. Studies to date on these techniques have been inconclusive (Akleyev 1995), and pilot efforts to continue the research are proposed because the potential return on the investment is very high.

External dose is related to the time integral of the dose rate field to which individuals were exposed. Information related to time is readily accessible through birthdates and residence histories.

Figure 22. Information Hierarchy for Estimating External Dose to EURT Early Evacuated Residents (and Unevacuated Areas)



Many historical measurements of radiation dose rate were made in the affected area immediately after the release and for many years afterward. These will provide the bulk of the necessary information. An additional promising source of external dose rate data is the use of environmental thermoluminescent materials. This technique has been shown to be effective (Bougrov 1995), but as is indicated in Table 5, it has not been used within the EURT zone. Some supporting information will also be provided by investigating classical radiation shielding calculations.

Historically measured radionuclide concentrations in many environmental media (including regional soils) are available. Curves of dose rate as a function of time are available for many villages, as are some radiation spectra. However, it is likely that reconstruction of contamination levels of some short-lived radionuclides will be required. This can be done using extrapolation in a few instances, but generally concentrations must be calculated from released amounts and the initial deposition pattern. The released amounts (source term) must be estimated from Mayak operating records and process descriptions. A parallel project at the Federal Nuclear Center in Snezhinsk (Chelyabinsk-70), managed by Dr. Evelina Kuropatenko, has a task to reconstruct the radionuclide release spectrum. Efforts will be coordinated with this group.

2.3.2 EURT Cohort External Dose Activity Descriptions

The following activities are necessary to complete the dose reconstruction process illustrated in Fig. 22.

Electron Paramagnetic Resonance (EPR) This subtask will perform additional measurements as tooth samples become available through routine dental work and postmortems (no active recruitment of samples from exposed individuals is planned). These measurements will be used as the basis for external dose for the affected individuals and also placed into a database from which statistical regressions based on age and residence can be made to provide a source of analog information for persons without direct measurements. It is anticipated that this subtask would be performed by staff of the Metal Physics Institute in Ekaterinbourg. Procurement of an EPR spectrometer will simplify and greatly increase the number of samples that could be analyzed annually.

Environmental Thermoluminescent Dosimetry (TLD) This subtask will perform initial measurements in environmental samples collected at predetermined locations within the EURT. A detailed sampling plan will be developed to optimize the number of samples required. The dose rates evaluated will be used to prepare a regression of dose rate for various locations. This will also serve to validate the radiation transport and shielding calculations.

Biodosimetry Pilot Study A feasibility study will be undertaken to evaluate the accuracy and reliability of measurements made with a suite of biodosimetric techniques, including fluorescent in-situ hybridization, T-cell receptor, and other techniques. If any of the techniques compare well with measurements made by other methods (EPR, etc.), further requests will be made to the JCCRER Executive Committee to incorporate the techniques into the ongoing dose reconstruction efforts.

Analysis of Historical and Current Monitoring Data This subtask will compile and evaluate available data on radionuclide concentrations in soils and associated dose rates. This information will serve as input to the individual dose calculations.

EURT Source Term Development This activity will prepare estimates of the radionuclide release to the air. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates. It is anticipated that staff from the Mayak Industrial Association will be key participants in this task, but that most efforts will be done by the staff of the Federal Nuclear Center in Snezhinsk.

EURT Cohort External Dose Estimation This task will provide management coordination and integration for the other subtasks involved with the EURT cohort. This task will assimilate the data and information prepared by the other tasks and make individual external dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

2.4 East Urals Radioactive Trace (EURT)- Internal Dose

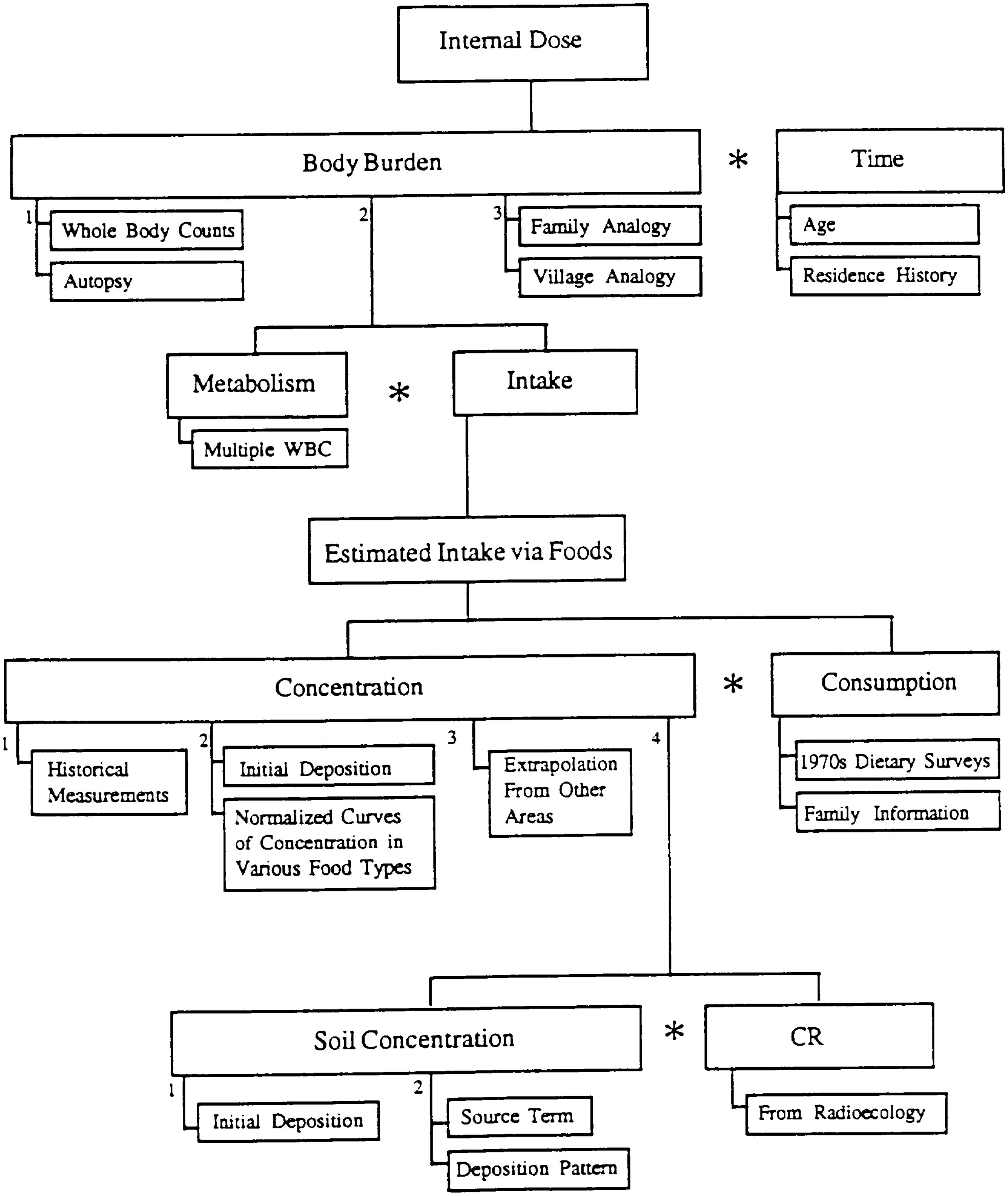
The internal dose reconstruction approach for residents exposed to the deposition forming the East Urals Radioactive Trace (EURT; also known as the "Kyshtym explosion") is described in Section 2.4.1. The tasks that derive from this approach are summarized in Section 2.4.2.

2.4.1 EURT Internal Dose Reconstruction Hierarchy

Residents of the area impacted by the EURT deposition may be divided into two groups (see Table 5)—those evacuated within the first days immediately following the release and those who were not evacuated. The general approach to internal dose reconstruction is generally used only for those who were not evacuated or who were only evacuated after a substantial time lapse.

The hierarchy of information required for calculating internal radiation doses to people who lived in the area impacted by the EURT release is shown in Fig. 23. Internal dose is related to the time integral of the body burden. Information related to time is readily accessible through birthdates and residence histories. As shown in Table 5, relatively few individuals have had whole body counts. These individual records are the preferred primary data for individual dose reconstruction, but will not support the bulk of the dose estimates for this cohort. A smaller number of individual autopsy data are available; these are also preferred starting points. The last resort for estimating body burden histories for individuals is via analogy to family members or residents of the same location - if individual measurements are not available, it is preferable to estimate them via individual intake and metabolic models.

Figure 23. Information Hierarchy for Estimating Internal Dose to EURT Late/Non-Evacuated Residents



There were a very large number of potential routes of ingestion of radionuclides. Eating various contaminated garden and field crops and animal products could all lead to intake of radionuclides. Consumption rates vary by age, sex, ethnic group, and perhaps by village. An extensive set of dietary questionnaires were administered to EURT residents in the 1970s. As a default, family or village food ingestion rates can be compiled.

Historically measured radionuclide concentrations in many selected environmental media (soil, crops, and animal products) are available. For many villages, there are time histories of the radionuclide concentration in multiple foods. These have been normalized into curves of concentration versus time for a unit initial deposition. These curves will provide the basic input for most individual dose reconstructions.

It is unlikely that reconstruction of food contamination levels will be required. This can be done using extrapolation in most instances. Concentrations could also be calculated from common radioecological transfer factors and estimated initial deposition. The released amounts (source term) must be estimated from Mayak operating records and process descriptions. This type of work is being undertaken by a parallel project at the Federal Nuclear Center in Snezhinsk (Chelyabinsk-70), managed by Dr. Evelina Kuropatenko, with a task to reconstruct the radionuclide release spectrum. Efforts will be coordinated with this group.

2.4.2 Techa River Cohort Internal Dose Activity Descriptions

The following activities are necessary to complete the full dose reconstruction illustrated in Fig. 23.

Evaluation of Bioassay Data This subtask will evaluate available whole body count data and autopsy data. This will provide body burden/intake estimates for individuals for whom measurements exist. This task will also assemble a database of whole body count derived body burdens for each family or village to be used as surrogates in case other approaches fail for unmeasured individuals.

Establish Food Consumption Rates This subtask will develop individual dietary intakes of various foods as functions of age, sex, ethnicity, and location. The efforts will use individual dietary information, and results of local surveys.

Analysis of Historical and Current Monitoring Data This subtask will compile and evaluate available data on radionuclide concentrations in soil and food. Curves of radionuclide content in foods versus time for a unit deposition will be verified and/or developed. This information will serve as the basis for most individual ingestion reconstruction.

EURT Source Term Development This activity will prepare estimates of the radionuclide release to the air. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates. It is anticipated that staff from the

Mayak Industrial Association will be key participants in this task, but that most efforts will be done by the staff of the Federal Nuclear Center in Snezhinsk.

EURT Cohort Internal Dose Estimation This task will provide management coordination and integration for the other subtasks involved with the Techa cohort. This task will assimilate the data and information prepared by the other tasks and make individual internal dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

2.5 Ozersk Residents—External Dose

Use of the Ozersk cohort in an epidemiological study is not yet certain. A pilot study is first suggested to determine if there is sufficient statistical power to resolve health effects in the exposed population. However, because other residents near the Mayak facility were impacted by the gaseous and aerosol releases from the facility, most of the following activities will be required to complete the dose estimation for the Techa (and possibly EURT) cohorts.

The external dose reconstruction approach for residents of the city of Ozersk (Chelyabinsk-65) is described in Section 2.5.1. The tasks that derive from this approach are summarized in Section 2.5.2.

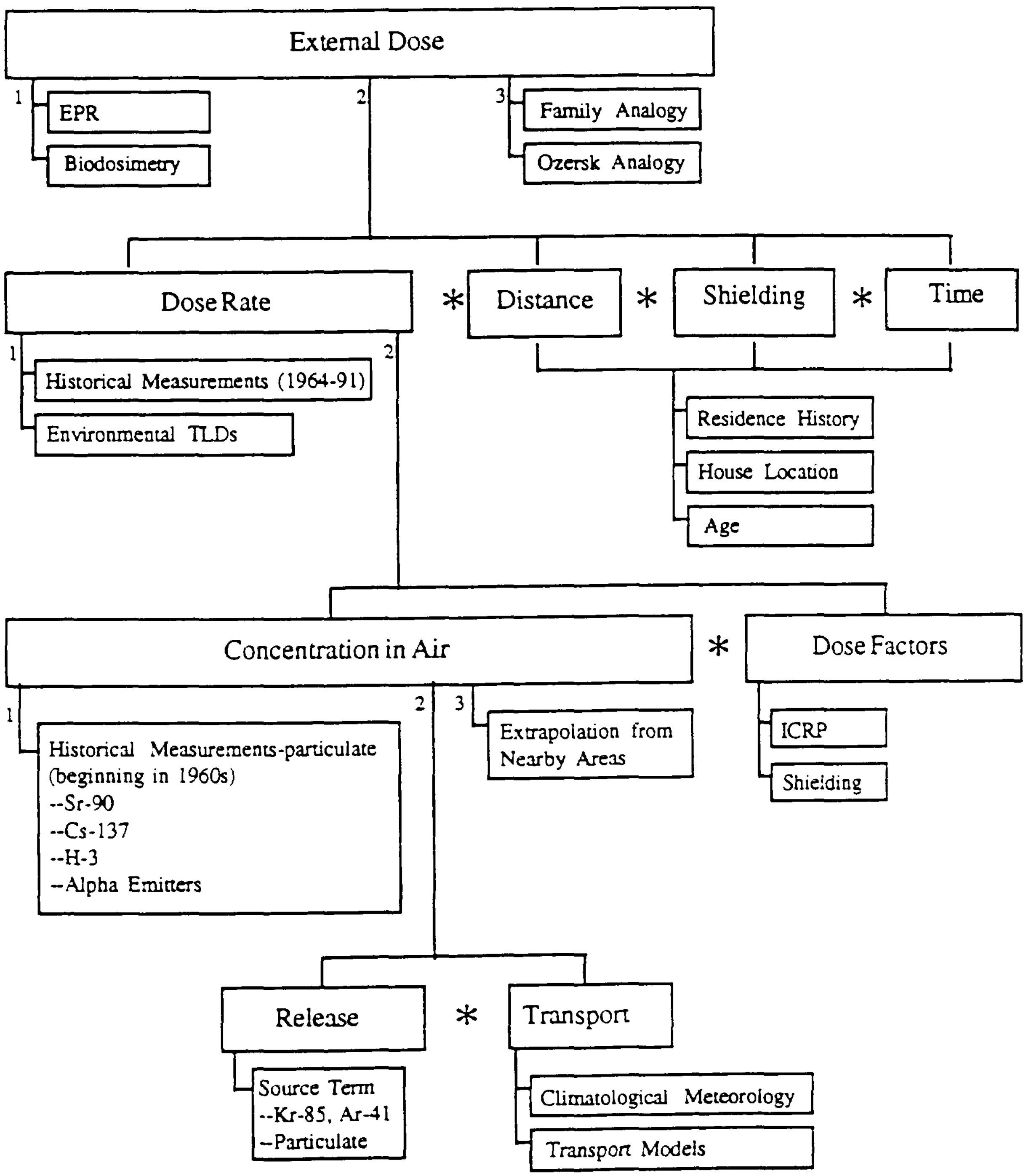
2.5.1 Ozersk Cohort External Dose Reconstruction Hierarchy

The hierarchy of information required for calculating external radiation doses to people who lived in Ozersk during the releases is shown in Fig. 24. Measurements of tooth samples made with Electron Paramagnetic Resonance techniques have been shown to give very reliable and accurate indications of absorbed dose. This would be the highest priority technique for determining external exposure; however, from Table 5 it is apparent that few individuals have been measured to date. Initiation of studies of this type is proposed. In addition, there is interest to evaluate whether biodosimetric techniques (e.g., fluorescent in-situ hybridization, T-Cell receptor, and others) can provide reliable estimates of external dose. Studies to date on these techniques have been inconclusive (Akleyev 1995), and pilot efforts to continue the research are proposed because the potential return on the investment is very high.

External dose is related to the time integral of the dose rate field to which individuals were exposed. Information related to time is readily accessible through birthdates and residence histories.

Some historical measurements of radiation dose rate were made in the vicinity of Ozersk. Most of these were made beginning in 1964, after the period of greatest release. Current environmental measurements can provide information about recent exposures; however, they lack any details of the earlier exposures. A promising source of external dose rate data is the use of environmental thermoluminescent materials. This technique has been shown to be effective

Figure 24. Information Hierarchy for Estimating External Dose to Ozersk Children



(Bougrov 1995), but as is indicated in Table 5, to date it has not been used in Ozersk. Thus, it will be necessary to also approach the problem by investigating classical radiation shielding calculations.

Historically measured concentrations of some selected radionuclides in air are available. However, the record only begins for these in the 1960s. Reconstruction of contamination levels will be required. This can be done using extrapolation in a few instances, but generally concentrations must be calculated from released amounts and an atmospheric transport model. The released amounts (source term) must be estimated from Mayak operating records and process descriptions. Atmospheric data available at this time are limited to climatological records - it is not yet known if hourly data (or equivalent) can be obtained.

2.5.2 Ozersk Cohort External Dose Activity Descriptions

The following activities are necessary to complete the dose reconstruction process illustrated in Fig. 24.

Epidemiological Feasibility Study This subtask will perform an initial evaluation of potential statistical power that an epidemiological study might have. Inputs will come from earlier studies performed by the Mayak Industrial Association. The results will be provided to the participants - it is anticipated that the decision to continue studies of the Ozersk cohort will be coordinated by the staff of FIB-1.

Electron Paramagnetic Resonance (EPR) This subtask will perform initial measurements as tooth samples become available through routine dental work and postmortems (no active recruitment of samples from exposed individuals is planned). These measurements will be used as the basis for external dose for the affected individuals and also placed into a database from which statistical regressions based on age and residence can be made to serve as a source of analog information for persons without direct measurements. It is anticipated that this subtask would be performed by staff of the Metal Physics Institute in Ekaterinbourg. Procurement of an EPR spectrometer will simplify and greatly increase the number of samples that could be analyzed annually.

Environmental Thermoluminescent Dosimetry (TLD) This subtask will perform initial measurements in environmental samples collected at predetermined locations within Ozersk. A detailed sampling plan will be developed to optimize the number of samples required. The dose rates evaluated will be used to prepare a regression of dose rate for various locations away from the Mayak facilities.

Biodosimetry Pilot Study A feasibility study will be undertaken to evaluate the accuracy and reliability of measurements made with a suite of biodosimetric techniques, including fluorescent in-situ hybridization, T-cell receptor, and other techniques. If any of the techniques compare well with measurements made by other methods (EPR, etc.), further requests will be made to the JCCRER Executive Committee to incorporate the techniques into the ongoing dose reconstruction efforts.

Analysis of Historical and Current Monitoring Data This subtask will compile and evaluate available data on radionuclide concentrations in air and soils. This information will serve as input to the source term and shielding subtasks.

Atmospheric Source Term Development This subtask will prepare estimates of the time history of radionuclide release to the atmosphere from Mayak activities. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task will develop estimated release fractions and prepare release estimates for use in atmospheric transport modeling. Radionuclides will include ^{131}I, ^{239}Pu, ^{137}Cs, ^{41}Ar, (^{85}Kr?), and others. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates. It is anticipated that staff from the Mayak Industrial Association will be key participants in this task.

Atmospheric Transport Modeling This subtask will accumulate meteorological data describing the historical dispersion conditions. This will be used as input to a numerical transport model to simulate the advection, dispersion, and wet and dry deposition of radionuclides. The model will provide concentrations of radionuclides in the air and on the ground at specified locations throughout the Mayak region.

Ozersk Cohort External Dose Estimation This task will provide management coordination and integration for the other subtasks involved with the Ozersk cohort. This task will assimilate the data and information prepared by the other tasks and make individual external dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

2.6 Ozersk Residents - Internal Dose

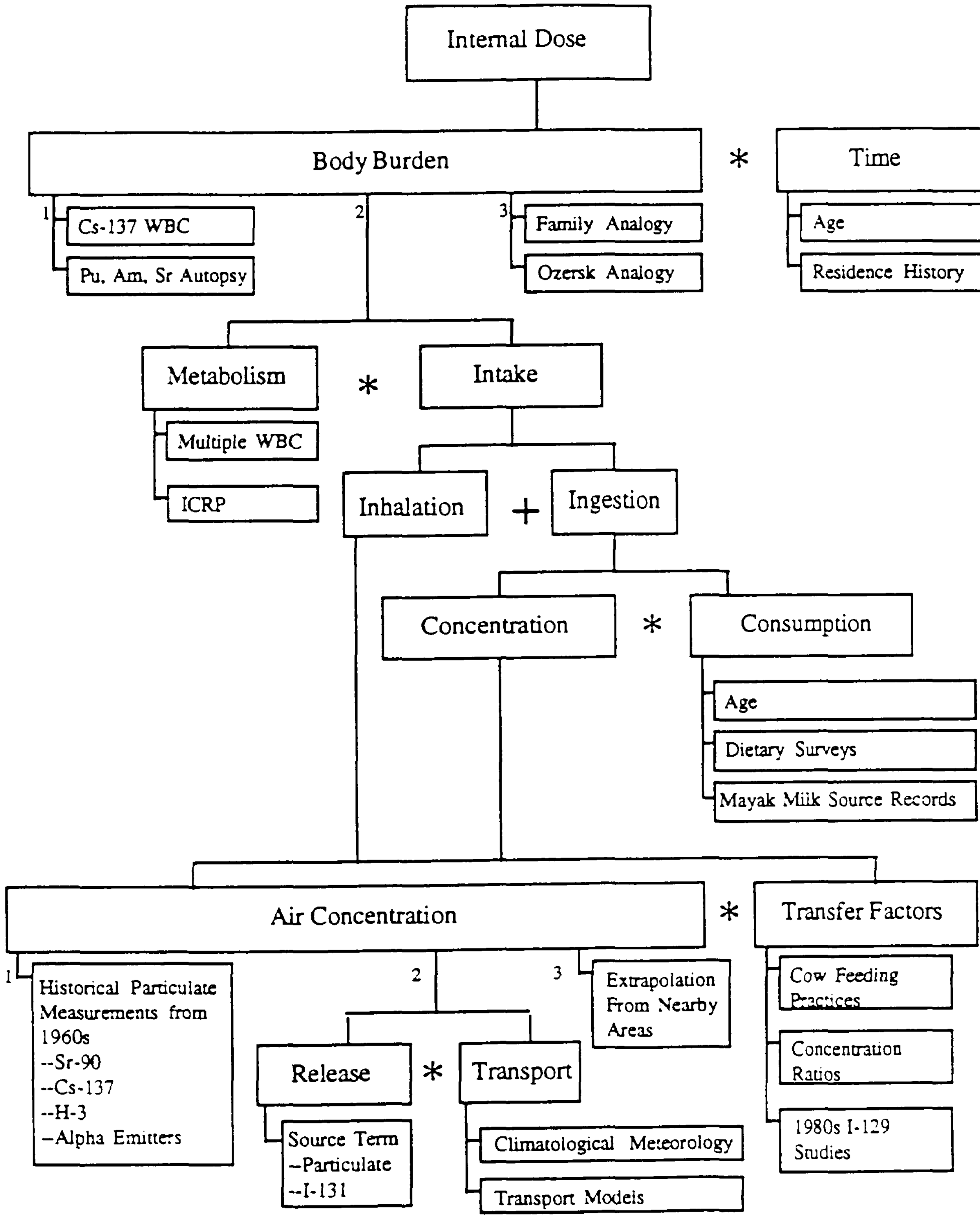
Use of the Ozersk cohort in an epidemiological study is not yet certain. A pilot study is first suggested to determine if there is sufficient statistical power to resolve health effects in the exposed population. However, because other residents near the Mayak facility were impacted by the gaseous and aerosol releases from the facility, most of the following activities will be required to complete the dose estimation for the Techa (and possibly EURT) cohorts. (Those activities required in either case are indicated in Section 4.3).

The internal dose reconstruction approach for residents of the City of Ozersk is described in Section 2.6.1. The tasks that derive from this approach are summarized in Section 2.6.2.

2.6.1 Ozersk Cohort Internal Dose Reconstruction Hierarchy

The hierarchy of information required for calculating internal radiation doses to people who lived in the vicinity of Ozersk during the releases is shown in Fig. 25. Internal dose is related to the time integral of the body burden. Information related to time is readily accessible through

Figure 25. Information Hierarchy for Estimating Internal Dose to Ozersk Children



birthdates and residence histories. As shown in Table 5, a number of individuals have had at least one whole body count; however, these did not begin until relatively late in the release period and consider only the readily-assessed gamma-emitting radionuclides. Individual autopsy records are also available for ^{137}Cs, plutonium, and ^{241}Am beginning in about 1975. These individual records are the preferred primary data for individual dose reconstruction, but none of these sources address what is potentially the key radionuclide—^{131}I. The last resort for estimating body burden histories for individuals is via analogy to family members or residents of the same location - if individual measurements are not available, it is preferable to estimate them via individual intake and metabolic models.

There were a very large number of potential routes of ingestion of radionuclides. Drinking milk probably lead to the largest exposures of ^{131}I in the early years, but inhalation is the leading pathway for doses from plutonium.

Consumption rates vary by age and sex. In the 1970s, dietary surveys were made of people living in the EURT areas - this data could provide some default information if individual dietary preferences are not available. Some information has been compiled by Mayak staff regarding sources of milk and other foods consumed in Ozersk. Collective farms in the area have provided milk to the Ozersk population and their production records are available. Additionally, studies were made in the 1980s of emission rates and environmental concentrations of ^{129}I; these could provide valuable information applicable to ^{131}I transfer in the region.

Historically measured radionuclide concentrations in some selected environmental media (^{137}Cs and ^{90}Sr in foods between 1956-1989, and ^{131}I in milk between 1962-1964) are available. Measurements of particulate radionuclides and tritium in air are available from the 1960s onwards. However, reconstruction of food-contamination levels will be required. This can be done using extrapolation in a few instances, but generally concentrations must be calculated from common radioecological transfer factors and estimated atmospheric concentrations. Air concentration must be estimated from released amounts and an atmospheric transport model. The released amounts (source term) must be estimated from Mayak operating records and process descriptions.

2.6.2 Ozersk Cohort Internal Dose Activity Descriptions

The following activities are necessary to complete the full dose reconstruction illustrated in Fig. 25.

Epidemiological Feasibility Study This subtask will perform an initial evaluation of potential statistical power that an epidemiological study might have. Inputs will come from earlier studies performed by the Mayak Industrial Association. The results will be provided to the participants—it is anticipated that the decision to continue studies of the Ozersk cohort will be coordinated by the staff of FIB-1.

Evaluation of Bioassay Data This subtask will evaluate available whole body count data and autopsy data. This will provide body burden/intake estimates for individuals for whom measurements exist. This task will also assemble a database of whole body count derived body burdens for each family or village to be used as surrogates in case other approaches fail for unmeasured individuals.

Establish Food-Consumption Rates This subtask will develop individual dietary intakes of various foods and water as functions of age, sex, ethnicity, and location. The efforts will use individual dietary information, results of local surveys, and information on the sources of drinking water.

Analysis of Historical and Current Monitoring Data This subtask will compile and evaluate available data on radionuclide concentrations in air, soil, and food. This information will serve as input to the radioecology and atmospheric transport subtasks.

Radioecology This subtask will review available data to determine the most appropriate transfer factors for radionuclides in milk and food crops. Sources of data may include site-specific measurements as well as generic sources such as the International Union of Radioecologists. This information will be used to develop estimates of radionuclide content in food crops. Additionally, information will be developed concerning the feeding practices for dairy cattle and distribution systems for milk and other foods produced in the area.

Atmospheric Source-Term Development This subtask will prepare estimates of the time history of radionuclide release to the atmosphere. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task will develop estimated release fractions and prepare release estimates for use in transport modeling. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates. It is anticipated that staff from the Mayak Industrial Association will be key participants in this task.

Atmospheric Transport Modeling This subtask will accumulate meteorological data describing the historical dispersion conditions. This will be used as input to a numerical transport model to simulate the advection, dispersion, and wet and dry deposition of radionuclides. The model will provide concentrations of radionuclides in the air and on the ground at specified locations throughout the Mayak region.

Ozersk Cohort Internal Dose Estimation This task will provide management coordination and integration for the other subtasks involved with the Ozersk cohort. This task will assimilate the data and information prepared by the other tasks and make individual internal dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

3. Project 1.1 Project Organization

The activities described in Section 2 are often parallel, and frequently one activity can support dose reconstruction for more than one cohort. It is therefore best to combine many of the activities into related tasks so that they may be better coordinated and managed.

3.1 Task 1: Project Management/Task Integration

(Project 1.1 Principal Investigators: M. Degteva, E. Drozhko, L. Anspaugh, B. Napier)

This task will provide overall direction and project management. This will include scheduling, financial control, meeting attendance, quality assurance, and peer review.

3.2 Task 2: Electron Paramagnetic Resonance Studies

(Metal Physics Institute: A. Romanyukha)

This task will coordinate and perform measurements as tooth samples become available through routine dental work and postmortems (no active recruitment of samples from exposed individuals is planned). Samples will be evaluated from each of the Techa River, EURT, and Ozersk cohorts. These measurements will be used as the basis for external dose for the effected individuals and also placed into a database from which statistical regressions based on age and residence can be made to serve as a source of analog information for persons without direct measurements. Procurement of an EPR spectrometer will simplify and greatly increase the number of samples that could be analyzed annually.

3.3 Task 3: Biodosimetry Pilot Studies

(Urals Research Center for Radiation Medicine: A. Akleyev)

A feasibility study will be undertaken to evaluate the accuracy and reliability of measurements made with a suite of biodosimetric techniques, including fluorescent in-situ hybridization, T-cell receptor, and other techniques. If any of the techniques compare well with measurements made by other methods (EPR, etc.), further requests will be made to the JCCRER Executive Committee to incorporate the techniques into the ongoing dose reconstruction efforts.

3.4 Task 4: Thermoluminescent Dosimetry Studies

(Urals Research Center for Radiation Medicine: N. Bougrov)

This task will perform initial measurements of environmental samples collected at predetermined locations along the Techa River, within the EURT, and within Ozersk. Detailed sampling plans will be developed to optimize the number of samples required. The dose rates evaluated will be used to prepare a regression of dose rate for various locations away from the Mayak facilities.

3.5 Task 5: Analysis of Historical Monitoring Data

(Urals Research Center for Radiation Medicine: M. Vorobiova)

This task will collect and interpret historical measurements of dose rate and radionuclide concentration in water, sediment, soil, fish, air, crops, and animal products. Specific data sets will be prepared for the Techa River between the Mayak release point and the confluence with the Iset River, the East Urals Radioactive Trace for inhabited areas with initial depositions greater than 0.01 Ci km^{-2}, and regions within 50 kilometers of the Mayak facility in which food crops or animal products were produced. These data sets will indicate the time histories of contamination where possible.

3.6 Task 6: Analysis of Bioassay Data

(Urals Research Center for Radiation Medicine: V. Kozheurov; FIB-1: K. Suslova)

This task is subdivided into four subtasks.

Subtask 6A: Evaluation of Available Data
(URCRM: V. Kozheurov; FIB-1: K. Suslova)

This subtask will collect and analyze existing whole body count and autopsy data. Databases will be prepared for the Techa River, EURT, and Ozersk cohorts. This will provide body burden/intake estimates for individuals for whom measurements exist. This task will also assemble a database of whole body count derived body burdens for each family or village to be used as surrogates in case other approaches fail for unmeasured individuals.

Subtask 6B: Calibration of SICH-9.1 Whole Body Counter
(URCRM: V. Kozheurov; Institute of Marine Transport Hygiene, St. Petersburg: A. Kovtun)

This subtask will continue the work begun in the feasibility stage of Project 1.1 in calibrating the URCRM whole body counter. A physical phantom has been designed and is being constructed to aid in this calibration; a mathematical phantom will also be prepared. This calibration is necessary to provide continuity and verification of the thousands of whole body counts available at URCRM.

Subtask 6C: Continued WBC Acquisition
(URCRM: V. Kozheurov)

This subtask supports continued data gathering and counting of the various cohorts. This is important for all aspects of the dose reconstruction as well as supporting the public outreach efforts of URCRM in the impacted populations. In order to most expeditiously continue this work, new detectors and electronics are required for the SICH-9.1 whole body counter. This subtask supports purchase and installation of this new equipment.

Subtask 6D: Metabolism Studies
(URCRM: V. Kozheurov, E. Tolstykh)
This subtask will use available sequential whole body count data to update radionuclide retention functions. This metabolic model would then be used to help evaluate all whole body counts to provide the integral exposures.

Subtask 6E: Tooth Count Analysis
(URCRM: V. Kozheurov)

This subtask will extend the technique of Kozheurov and Degteva (1994) for dietary intake evaluation based on in vivo measurements of strontium-90 in teeth beyond the village of Muslymovo, where it was developed, to other sites along the Techa River.

3.7 Task 7: Individual Definition/Epidemiological Interface
(URCRM: M. Degteva)

This task will coordinate the development of individual dietary intakes of various foods and water as functions of age, sex, ethnicity, and location. The efforts will use individual dietary information, results of local surveys, and information on the sources of drinking water. This task will also support the continued validation of individual residence histories for members of each cohort. This task will coordinate the assignment of family or village analogs, where required, to individuals under assessment.

3.8 Task 8: Radioecology/Transfer Factors
(URCRM: M. Vorobiova; MIA: G. Romanov)

This task will review available data to determine the most appropriate transfer factors for radionuclides in fish, milk, and food crops. Sources of data may include site-specific measurements as well as generic sources such as the International Union of Radioecologists. This information will be used to develop estimates of radionuclide content in food crops. This effort will be coordinated with the available monitoring data collected in Task 5.

3.9 Task 9: Techa River Source Term Development
(MIA: Yu. Mokrov)

This task will prepare estimates of the time history of radionuclide release to the Techa River. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task will develop estimated release fractions and prepare release estimates for use in transport modeling. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates.

3.10 Task 10: Atmospheric Source Term Development
(MIA: V.V. Khokhryakov; Federal Nuclear Center: E. Kuropatenko)

This task will prepare estimates of the time history of radionuclide release to the atmosphere from Mayak activities. This will require review of historical Mayak documents regarding facility operating histories, technological processes involved, and any available measurements of releases. This task will develop estimated release fractions and prepare release estimates for use in atmospheric transport modeling. Radionuclides will include ^{131}I, ^{239}Pu,

^{137}Cs, ^{41}Ar, (^{85}Kr?), and others. This task may involve review of currently classified documents. Provisions will be made to declassify key documents supporting the release estimates.

Reasonably complete information is available for the atmospheric release from the explosion that formed the East Urals Radioactive Trace. However, work is being undertaken by a parallel project at the Federal Nuclear Center in Snezhinsk (Chelyabinsk-70), managed by Dr. Evelina Kuropatenko, under a task to reconstruct the radionuclide release spectrum. Efforts will be coordinated with this group.

3.11 Task 11: Techa River Radionuclide Transport Modeling
(URCRM: D. Burmistrov)

This task has two subtasks.

Subtask 11A: Radionuclide Transport Modeling
(URCRM: D. Burmistrov, M. Vorobiova)

This subtask will accumulate data describing the historical Techa River hydrologic data, sediment loading, and dam construction history. This will be used as input to a numerical transport model to simulate the flow and contaminant loading of the Techa River from the Mayak facility to its confluence with the Iset River. The model will provide concentrations of radionuclides in water and sediment at specified locations along the river.

Subtask 11B: Radiation Transport/Shielding
(URCRM: D. Burmistrov)

This subtask will also use the modeled river concentrations to extend available measurements (from TLD and conventional sources) to provide dose rates as a function of location away from the Techa River. Inputs to the modeling will generally come from the Techa River source term and transport modeling activities. Additional calculations may be performed to estimate external doses from noble gases released to the atmosphere.

3.12 Task 12: Atmospheric Transport Modeling
(MIA: V.V. Khokhryakov)

This task will accumulate meteorological data describing the historical dispersion conditions. This will be used as input to a numerical transport model to simulate the advection, dispersion, and wet and dry deposition of radionuclides. The model will provide concentrations of radionuclides in the air and on the ground at specified locations throughout the Mayak region.

3.13 Task 13: Dose Estimation for Techa Cohort
(Project 1.1 Principal Investigators: M. Degteva, E. Drozhko, L. Anspaugh, B. Napier)

This task will provide management coordination and integration for the other subtasks involved with the Techa cohort. This task will assimilate the data and information prepared by the other tasks and make individual internal and external dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed Techa River cohort results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the Techa River cohort individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

3.14 Task 14: Dose Estimation for EURT Cohort

(Project 1.1 Principal Investigators: M. Degteva, E. Drozhko, L. Anspaugh, B. Napier)

This task will provide management coordination and integration for the other subtasks involved with the EURT cohort. This task will assimilate the data and information prepared by the other tasks and make individual internal and external dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed EURT cohort results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the EURT cohort individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

3.15 Task 15: Dose Estimation for Ozersk Cohort

(Project 1.1 Principal Investigators: M. Degteva, E. Drozhko, L. Anspaugh, B. Napier; FIB-1: K. Suslova)

This task will provide management coordination and integration for the other subtasks involved with the Ozersk cohort. Following the epidemiology feasibility study, this task will assimilate the data and information prepared by the other tasks and make individual internal and external dose estimates based on the priority of the data hierarchy. This task will also collect a database of completed Ozersk cohort results to use as potential surrogates for use in estimating individual doses by analogy as a last resort. This task will also lead the evaluation of uncertainty in the Ozersk cohort individual dose estimates and use the collected information to attempt to validate the more numerically-intensive techniques against those with better measurements.

4. Cohort Summary Schedules

A summary schedule, showing estimated staffing requirements, time lines, task interdependencies, and milestones, is provided for each of the three dose-reconstruction cohorts.

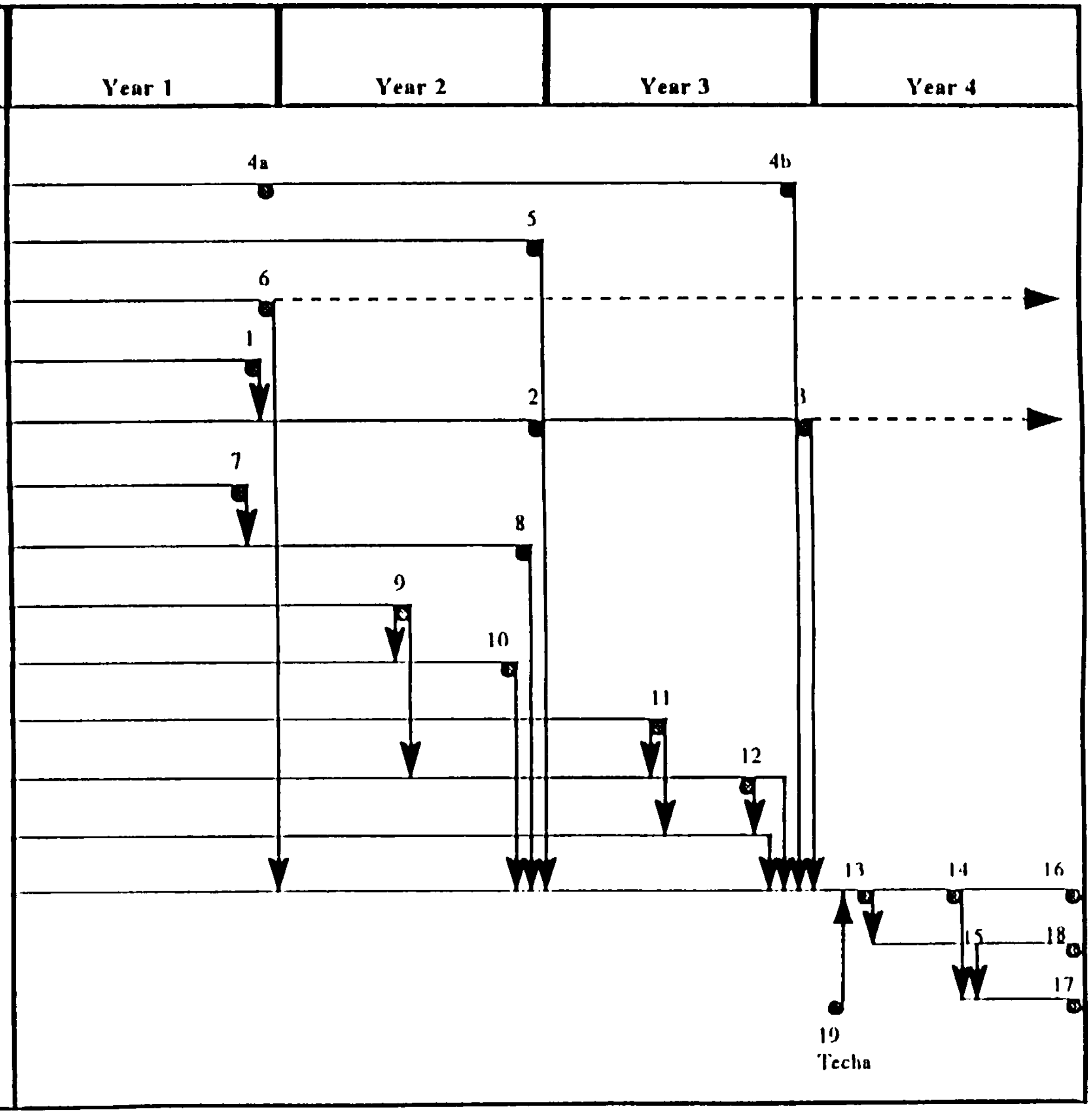
4.1 Techa River Cohort Summary Schedule

Fig. 26 illustrates the summary schedule for the Techa River cohort. The activities listed are described in Sections 2.1.2 and 2.2.2. The connections illustrated generally represent the last date on which data are exchanged between the activities; it is anticipated that the staff would be in continual communication and the important information would be shared as it is developed. The individual milestones, which may be published as separate reports by the participating authors, are:

1. Description of radionuclide metabolic models to assist in evaluation of bioassay data.

Figure 26. Schedule, Dependencies, and Milestones for Techa Cohorts

Techa Cohort Activity	Effort (person-years)
EPR	2
TLD	2
Biodosimetry	2
Metabolic Models	1
Bioassay Evaluation	6
Tooth Count Analysis	1
Food Consumption	1
Analysis of Monitoring Data	3
Radioecology	1
Techa Source Term	5
River Transport	3
Shielding	1
Dose Estimation	5
Uncertainty Analysis	1
Sensitivity Analysis	1
Atmospheric Input	--



2. Completion of updating and calibration of the SICH-9.1 whole body counter.
3. Final report on individual body burden histories and resulting doses evaluated for Techa River cohort.

4a. Completion of procurement, installation, and calibration of EPR spectrometer.

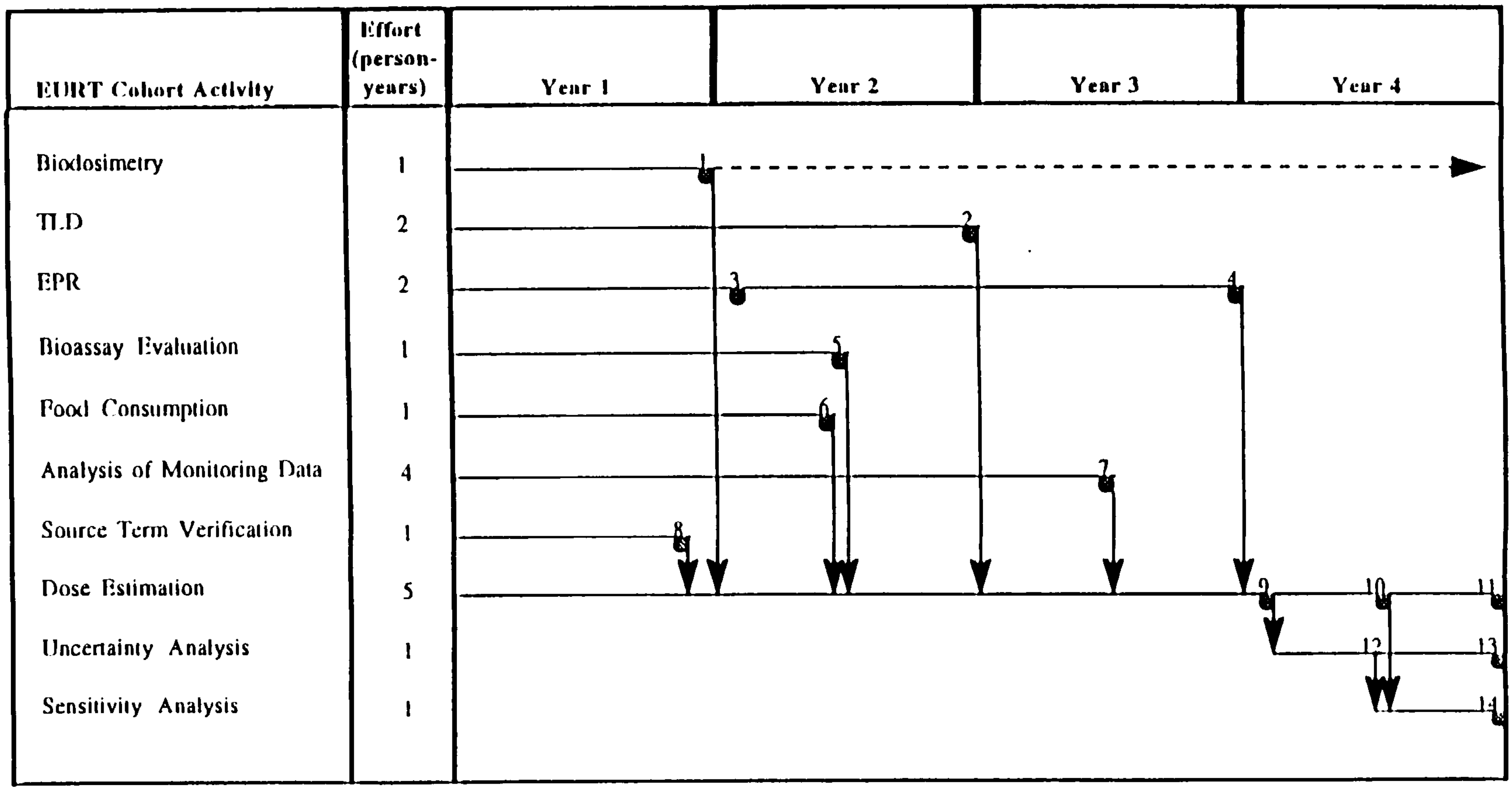
4b. Final report on individual external doses measured for specific individuals using EPR, and description of methodology for extrapolating to other individuals in the Techa River cohort.

5. Final report on environmental thermoluminescent dosimetry measurements and description of methodology for extrapolating to other individuals in the Techa River cohort.
6. Final report of feasibility study on use of biodosimetric techniques. If selected techniques are deemed to be useful, additional measurements would be proposed to the executive committee.
7. Final report of the dietary intake evaluation and dosimetric modeling for the Techa River residents based on in-vivo measurements of radionuclides in teeth, to be used as input to the development of individual dietary information.
8. Final report on development of individual dietary information.
9. Final report on historically measured dose rates, radionuclide concentrations in water, sediment, soils, and foods.
10. Final report on default transfer factors for use in estimating radionuclide concentrations in fish, crops, and animal products, including references and derivations.
11. Final report on derivation of the radionuclide release rates from Mayak facilities to the Techa River. Includes time histories of individual radionuclides.
12. Final report of modeled concentrations of radionuclides in Techa River water and sediments at specified locations over time. Includes description of hydrologic data and model(s) employed.
13. Initial individual dose models and estimates for specific individuals for uncertainty analysis.
14. Refined individual dose estimates for use in sensitivity analysis.
15. Description of uncertainty in individual dose estimates for use in sensitivity analysis.
16. Final report to epidemiological study on radiation doses to individuals within the Techa River cohort.
17. Final report on parameters resulting in uncertainty in the individual doses.
18. Final report on uncertainties associated with radiation doses for individuals within the Techa River cohort.
19. Placeholder milestone to indicate connection with analyses for the Ozersk cohort for atmospheric pathways. Data regarding dose from atmospheric releases is input here (Section 4.3, Milestone 14).

4.2 EURT Cohort Summary Schedule

Fig. 27 illustrates the summary schedule for the EURT cohort. The activities listed are described in Sections 2.3.2 and 2.4.2. The connections illustrated generally represent the last date on which data are exchanged between the activities; it is anticipated that the staff would be in continual communication and the important information would be shared as it is developed. The individual milestones, which may be published as separate reports by the participating authors, are:

Figure 27. Schedule, Dependencies, and Milestones for EURT Cohorts



1. Final report of feasibility study on use of biodosimetric techniques. If selected techniques are deemed to be useful, additional measurements would be proposed to the executive committee.
2. Final report on environmental thermoluminescent dosimetry measurements and description of methodology for extrapolating to other individuals in the EURT cohort.
3. Completion of procurement, installation, and calibration of EPR spectrometer.
4. Final report on individual external doses measured for specific individuals using EPR, and description of methodology for extrapolating to other individuals in the EURT cohort.
5. Final report on individual body burden histories and resulting doses evaluated for the EURT cohort.
6. Final report on development of individual dietary information.
7. Final report on historically measured dose rates, radionuclide concentrations in water, sediment, soils, and foods. Includes default transfer factors for use in estimating radionuclide concentrations crops and animal products, including references and derivations.
8. Final report on derivation of the radionuclide release from the Kyshtym explosion to the atmosphere. It is anticipated that this report will be prepared by a parallel project.
9. Initial individual dose models and estimates for specific individuals for uncertainty analysis.
10. Refined individual dose estimates for use in sensitivity analysis.
11. Final report to epidemiological study on radiation doses to individuals within the EURT cohort.
12. Description of uncertainty in individual dose estimates for use in sensitivity analysis.
13. Final report on uncertainties associated with radiation doses for individuals within the EURT cohort.
14. Final report on sensitive parameters resulting in uncertainty in the individual doses for the EURT cohort.

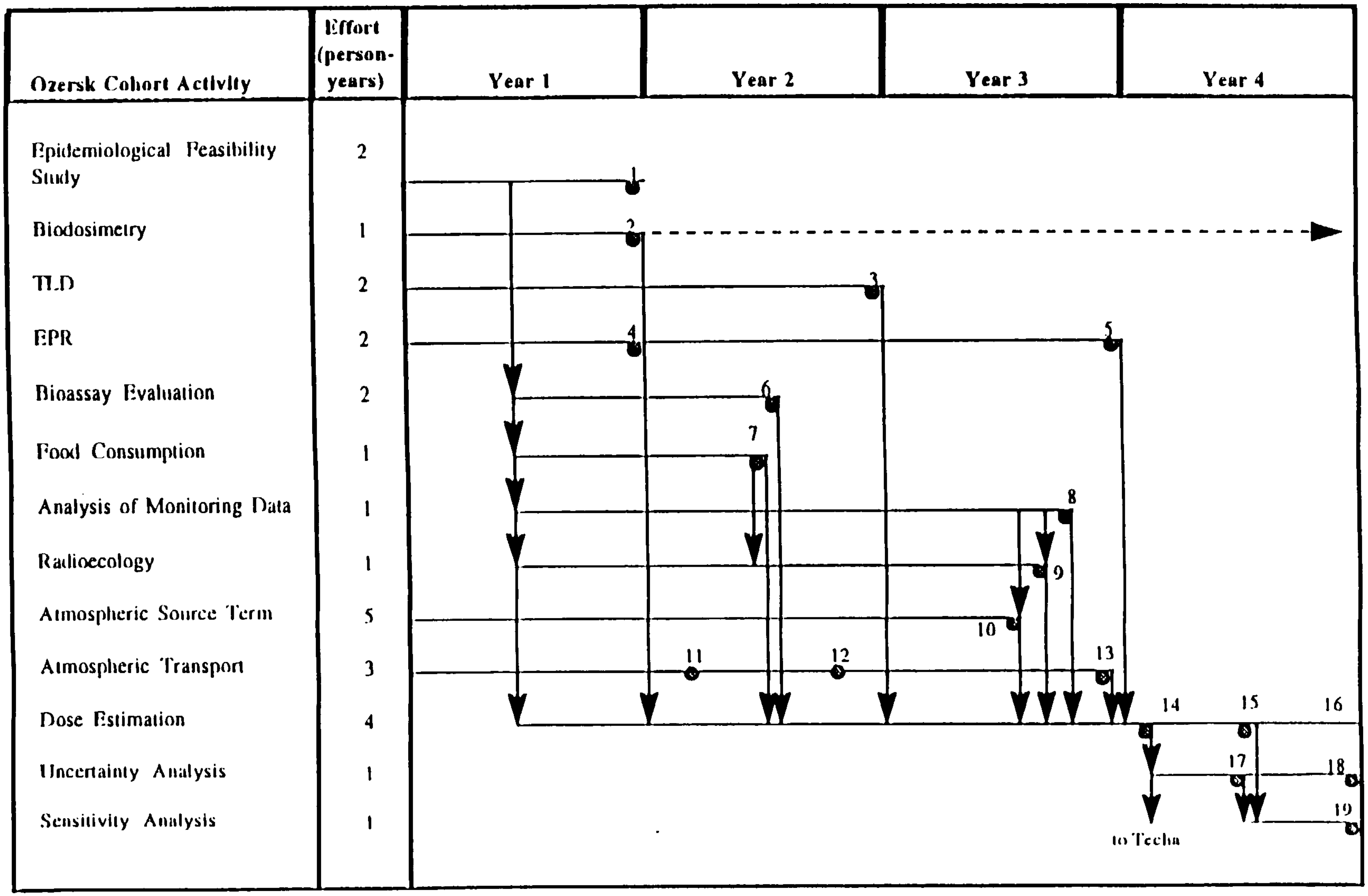
4.3 Ozersk Cohort Summary Schedule

Fig. 28 illustrates the summary schedule for the Ozersk cohort. The activities listed are described in Sections 2.5.2 and 2.6.2. This set of activities begins with a one-year feasibility study to determine if the efforts are required - however, several of the tasks will be performed in conjunction with studies for the Techa River and EURT cohorts. Thus, while some of the activities do not begin until after the completion of the feasibility study, others are required whether or not the Ozersk cohort is studied. These are assumed to begin at the same time as the other efforts.

The connections illustrated generally represent the last date on which data are exchanged between the activities; it is anticipated that the staff would be in continual communication and the important information would be shared as it is developed. The individual milestones, which may be published as separate reports by the participating authors, are:

1. Final report on the feasibility study evaluating the statistical power of an epidemiological study of the Ozersk cohort. A decision should be reached prior to the publication of this report - a positive determination would result in work beginning on subsequent tasks prior to the report's final release.

Figure 28. Schedule, Dependencies, and Milestones for Ozersk Cohorts



2. Final report of feasibility study on use of biodosimetric techniques. If selected techniques are deemed to be useful, additional measurements would be proposed to the executive committee.
3. Final report on environmental thermoluminescent dosimetry measurements and description of methodology for extrapolating to other individuals in the Ozersk cohort.
4. Completion of procurement, installation, and calibration of EPR spectrometer.
5. Final report on individual external doses measured for specific individuals using EPR, and description of methodology for extrapolating to other individuals in the Ozersk cohort.
6. Final report on individual body burden histories and resulting doses evaluated for the Ozersk cohort.
7. Final report on development of individual dietary information.
8. Final report on historically measured dose rates, radionuclide concentrations in air, soils, and foods.
9. Final report on default transfer factors for use in estimating radionuclide concentrations in crops and animal products, including references and derivations.
10. Final report on derivation of the radionuclide release rates from Mayak facilities to the atmosphere. Includes time histories of individual radionuclides - noble gases, reactive gases, and iodines.
11. Evaluation of meteorological data availability and selection of modeling approach.
12. Final development of atmospheric dispersion model.
13. Final report of modeled concentrations of radionuclides in air and deposited on the ground at specified locations over time. Includes description of meteorological data and model(s) employed.
14. Initial individual dose models and estimates for specific individuals for uncertainty analysis. This information is also provided for the Techa River cohort at this time.
15. Refined individual dose estimates for use in sensitivity analysis.
16. Final report to epidemiological study on radiation doses to individuals within the Ozersk cohort.
17. Description of uncertainty in individual dose estimates for use in sensitivity analysis.
18. Final report on parameters resulting in uncertainty in the individual doses.
19. Final report on uncertainties associated with radiation doses for individuals within the Ozersk cohort.

APPENDIX B:

CURRICULA VITAE OF THE PRIMARY PARTICIPANTS

CURRICULUM VITAE

Name: **Marina O. Degteva**

Date and place of birth: October 11, 1951, Ekaterinburg, Russia

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Education: 1969-1976 Dept. of Physics, Moscow State University, Russia

Scientific degree: Ph.D., 1990 Moscow Biophysics Institute, Dose Assessment Models for Beta-emitting Nuclides of Alkaline Earth Elements."

Professional Experience: 1976-Present: Staff Member of Urals Research Center for Radiation Medicine, URCRM, former Branch No 4 of Moscow Biophysics Institute
1976-1986: Junior Scientist of Physics Laboratory;
1986: Temporary work in Belarus in connection with Chernobyl accident;
1987-1990: Scientist of Clinical Department;
1991-Present: Head of Biophysics Laboratory.

Field of Interest: Radiation dosimetry and risk assessment.

International Grants and Programs: PI of International Science Foundation (ISF) Grant No. NM5000 "Studies of Strontium Metabolism in Humans" 1994-1995.
PI of Russian-US Joint Coordinating Committee on Radiation Effects Research (JCCRER) Project 1.1 "Dose Reconstruction for the Urals Population" 1995-1996.

Scientific Publications: The author and co-author of over 50 scientific papers and technical reports related to the dose assessment and biological effects of radiation. Among them are the following:

Degteva, M.O., Kozheurov, V.P., and Vorobiova, M.I., General Approach to Dose Reconstruction in the Population Exposed as a Result of the Release of Radioactive Wastes into the Techa River, *Science Total Environ.* **142**, 49-62.(1994).

Degteva, M.O., Kozheurov, V.P., Tolstykh, E.I., and Kovtun, A.N., The Measuring and Modelling of Strontium-90: an Integrated Retrospective Dosimetry Issue. IRPA9: 1996 International Congress on Radiation Protection. Vienna, Austria, April 14-19, 1996. Vol. 1., pp. 417-424.

Degteva, M.O. and Kozheurov, V.P., Age-dependent Model for Strontium Retention in Human Bone, *Radiat. Protect. Dosimetry* **53**, 229-234 (1994).

Kozheurov, V.P., and Degteva, M.O. Dietary Intake Evaluation and Dosimetric Modelling for the Techa River Residents Based on in vivo Measurements of Strontium-90 in Teeth and Skeleton, *Science Total Environ.* **142**, 63-72 (1994).

Kossenko, M.M., and Degteva, M.O., Cancer Mortality and Radiation Risk Evaluation for the Techa River Population, Science Total Environ. **142**, 73-90 (1994).

Kossenko, M.M., Degteva, M.O., and Petrushova, N.A,. Leukemia Risk Estimate to Those Exposed as a Result of Nuclear Incidents in the Southern Urals, *PSR Quarterly* **2**(4), 187-197 (1992).

Romanyukha, A.A., Ignatiev, E.A., Degteva, M.O. et al., Retrospective Dosimetry for Survivors after Ural Waste Accidents. *Nature* (in press).

Romanyukha, A.A., Degteva, M.O., Kozheurov, V.P. et al., Pilot Study of the Population of the Ural Region with EPR Tooth Dosimetry. *Radiat. Environ Biophys.* (in press).

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Phone: 7 (351-51) 721 90

Education: 1965-1979 Moscow Engineer-Physical Institute. Moscow, Russia

Professional experience:

1971-1979 Engineer-Physicist of "Mayak" PA Central Laboratory

1979-1982 Head of Scientific Group of "Mayak" PA Central Laboratory.

1982-1986 Head of Scientific Laboratory of "Mayak" PA Central Laboratory

1986-1993 Deputy Chief Engineer of "Mayak" PA
1993-1996 Deputy Director of "Mayak" PA

Field of Interest: Environmental Protection, Radiation Safety.

Scientific publications: Author and co-author more than 50 scientific-technical reports and works on dosimetry and radiation safety. Among them:

Drozhko, E.G., Suslov, A.P., Fetisov, V.I., Glagolenko, Y.V., Medvedev, G.M. Osnovin, V.I., and Dzekun, E.G., Basic directions and problems of radioactive waste management program in the "Mayak" Production Association. In "High Level Radioactive Waste and Spent Fuel Management" Proc. of Int. Conf. on Nuclear Waste Management and Environmental Remediation., Prague, September 5-11, 1993.

Drozhko, E.G., Sharalapov, V.I., Posokhov, A.K., Kuzina, N.V., and Postovalova, G.A., History, Contamination and Monitoring of Water Bodies at the P/A "Mayak". In "High Level Radioactive Waste and Spent Fuel Management" Proc. of Int. Conf. on Nuclear Waste Management and Environmental Remediation., Prague, September 5-11, 1993.

Mokrov, G., Drozhko, E., Glagolenko, Y., and Smirnov, A., The Prospects of Usage of Information Data Base at the Production Association "Mayak" as for Modeling of the Ural Region Ecosystems. In "High Level Radioactive Waste and Spent Fuel Management" Proc. of Int. Conf. on Nuclear Waste Management and Environmental Remediation., Prague, September 5-11, 1993.

CURRICULUM VITAE

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Education: Nebraska Wesleyan University, Lincoln, NE, 1959, A.B. (Physics)
University of California at Berkeley, 1961 M.Biorad. (Health Physics)
University of California at Berkeley, 1963 Ph.D. (Biophysics)

Professional Experience: 1963-Present: Biophysicist, Lawrence Livermore National Laboratory; 1995-Present: Director, Dose Reconstruction Program; 1993-1995: Director, Risk Sciences Center; 1982-1992: Division Leader, Environmental Sciences Division; 1976-1982: Section Leader for Analysis and Assessment; 1974-1975: Group Leader for Applied Environmental Sciences; 1963-1974: Biomedical and Environmental Sciences; 1961-1963: National Science Foundation Graduate Fellow; 1959-1961: U.S.A.E.C. Special Fellowship in Radiological Physics

Honors: Fellow, Health Physics Society, 1989
Elected Member, National Council on Radiation Protection and Measurements (NCRP), 1989, 1995
Member, U.S. Delegation to the United Nations Scientific Committee on the Effects of Atomic Radiations, 1987-Present

Field of Interest: Radiation dose reconstruction

Scientific Publications: The author and co-author of more than 200 publications. Among these are the following:

L.R. Anspaugh, J.H. Shinn, P.L. Phelps, and N.C. Kennedy, "Resuspension and Redistribution of Plutonium in Soils," *Health Phys.* **29**, 571–582 (1975).

L.R. Anspaugh, "*In Situ* Methods for Quantifying Specific Radionuclides," *IEEE Trans. Nucl. Sci.* **23**, 1190-1196 (1976).

R.O. Gilbert, D.W. Engel, D.D. Smith, J.H. Shinn, L.R. Anspaugh, and G.R. Eisele, "Transfer of Aged Pu to Cattle Grazing on a Contaminated Environment," *Health Phys.* **54**, 323–335 (1988).

L.R. Anspaugh, R.J. Catlin, and M. Goldman, "The Global Impact of the Chernobyl Reactor Accident," *Science* **242**, 1513–1519 (1988).

R.O. Gilbert, D.W. Engel, and L.R. Anspaugh, "Transfer of Aged $^{239+240}Pu$, ^{238}Pu, ^{241}Am, and ^{137}Cs to Cattle Grazing a Contaminated Arid Environment," *Sci. Total Environ.* **85**, 53–62 (1989).

F.A. Mettler, W.K. Sinclair, L. Anspaugh, C. Edington, J.H. Harley, R.C. Ricks, P.B. Selby, E.W. Webster, and H.O. Wyckoff, "The 1986 and 1988 UNSCEAR Reports: Findings and Implications," *Health Phys.* **58**, 241–250 (1990).

L.R. Anspaugh, Y.E. Ricker, S.C. Black, R.F. Grossman, D.L. Wheeler, B.W. Church, and V.E. Quinn, "Historical Estimates of External γ Exposure and Collective External γ Exposure from Testing at the Nevada Test Site. II. Test Series after Hardtrack II, 1958, and Summary," *Health Phys.* **59**, 525–532 (1990).

R.T. Cederwall, Y.E. Ricker, P.L. Cederwall, D.N. Homan, and L.R. Anspaugh, "Ground-Based Air-Sampling Measurements Near the Nevada Test Site after Atmospheric Nuclear Tests," *Health Phys.* **59**, 533–540 (1990).

B.W. Church, D.L. Wheeler, C.M. Campbell, R.V. Nutley, and L.R. Anspaugh, "Overview of the Department of Energy's Off-Site Radiation Exposure Review Project (ORERP)," *Health Phys.* **59**, 503–510 (1990).

Y.C. Ng, L.R. Anspaugh, and R.T. Cederwall, "ORERP Internal Dose Estimates for Individuals," *Health Phys.* **59**, 693–713 (1990).

J.R. Kercher and L.R. Anspaugh, "Analysis of the Nevada-Applied-Ecology-Group Model of Transuranic Radionuclide Transport and Dose," *J. Environ. Radioact.* **13**, 191–216 (1991).

L.D. Hamilton, S. Holtzman, A.F. Meinhold, S.C. Morris, R. Pardi, M.D. Rowe, C. Sun, L.R. Anspaugh, K.T. Bogen, J.I. Daniels, D.W. Layton, T.E. McKone, T. Straume, R. Andricevic and R.L. Jacobson, "Pilot Study Risk Assessment for Selected Problems at Three U.S. Department of Energy Facilities," *Environ. Intl.* **20**, 585–604 (1994).

I.A. Likhtarev, L.N. Kovgan, S.E. Vavilov, R.R. Gluvchinsky, O.N. Perevoznikov, L.N. Litvinets, L.R. Anspaugh J.R. Kercher and A. Bouville, "Internal Exposure from the Ingestion of Foods Contaminated by ^{137}Cs after the Chernobyl Accident," *Health Phys.* **70**, 297-317 (1996).

G. Voigt, H.G. Paretzke, L. Anspaugh, M. Balonov, A. Bouville, V. Chumak, M. Crick, Y. Gavrilin, E. Haskell, P. Jacob, I. Kairo, Y. Kenigsberg, V. Khrouch, I. Likhtarev, V. Minenko, V. Stepanenko, T. Straume, A. Ulanovsky, A. Wieser, I. Zvonova, et al., "Scientific Recommendations for the Reconstruction of Radiation Doses Due to the Reactor Accident at Chernobyl," *Radiat. Environ. Biophys.* **35**, 1-9 (1996).

L.R. Anspaugh and J.I. Daniels, "Bases for Secondary Standards for Residual Radionuclides in Soil and Some Recommendations for Cost-Effective Operational Implementation," *Health Phys.* **70**, 722-734 (1966.).

T. Straume, A.A. Marchetti, L.R. Anspaugh, V.T. Khrouch, Y.I. Gavrilin, S.M. Shinkarev, V.V. Drozdovitch, A.V. Ulanovsky, S.V. Korneev, M.K. Brekeshev, E.S. Leonov, G. Voigt, S.V. Panchenko, and V.F. Minenko, "The Feasibility of Using ^{129}I to Reconstruct ^{131}I Deposition from the Chernobyl Reactor Accident," *Health Phys.* (in press).

L.R. Anspaugh, "Technical Basis for Dose Reconstruction," In *Proceedings of the 31st Annual Meeting of the National Council on Radiation Protection and Measurements, Arlington, VA, April 12-13, 1995* (in press).

CURRICULUM VITAE

Name:	**Bruce A. Napier**
Date and Place of Birth:	14 July 1953, Pittsburgh, PA, USA
Citizenship:	USA
Address:	Pacific Northwest National Laboratory P.O. Box 999 Richland, WA 99352
Education:	B.S. Nuclear Engineering, 1975, Kansas State University M.S. Nuclear Engineering, 1977, Kansas State University
Professional Experience:	1977-Present: Staff Member at Pacific Northwest National Laboratory, operated for the U.S. Department of Energy by the Battelle Memorial Institute 1977-1980: Scientist (I) 1981-1983: Research Scientist (II) 1983-1990: Senior Research Scientist (III) 1990-present: Staff Scientist (IV)
Professional certification:	American Board of Health Physics
Field of Interest:	Environmental health physics, dose reconstruction, radiological risk assessment and performance assessment, computer modeling, emergency response

Scientific publications: Author and co-author of over 150 book chapters, articles, reports, and presentations, including:

Napier, B.A., "Aquatic and Terrestrial Transport of Radionuclides," C.J. Maletskos, Ed., *Radiation Protection at Nuclear Reactors*, Medical Physics Publishing, Madison, Wisconsin (1995).

Napier, B.A. 1994. "Hanford Environmental Dose Reconstruction Project," *HPS Newsletter* **XXII**(6), 6-8, Health Physics Society (1994).

Shipler, D.B., B.A. Napier, W.T. Farris, M.D. Freshley. 1994. "The Hanford Environmental Dose Reconstruction Project - An Overview," submitted to *Health Physics*. (PNWD-SA-3959 HEDR).

Farris, W.T., B.A. Napier, T.A. Ikenberry, and D.B. Shipler. 1994. "Radiation Doses from Hanford Site Releases," submitted to *Health Physics*. (PNWD-3968 HEDR).

Gilbert, R. O., B. A. Napier, A. M. Liebetrau, and H. A. Haerer, "Statistical Aspects of Reconstructing the I-131 Dose to the Thyroid of Individuals Living Near the Hanford Site in the Mid-1940s," *Radiat. Protect. Dosim.* **36**, 195-198 (1991).

Gilbert, R. O., J. C. Simpson, B. A. Napier, H. A. Haerer, A. M. Liebetrau, A. J. Ruttenbur, and S. Davis, "Statistical Aspects of the Hanford Environmental Dose Reconstruction Project and the Hanford Thyroid Disease Study," *J. Radiation Research* **124**, 354-355 (1990).

Strenge, D.L., and B.A. Napier, "Radiological Assessment," *Engineering Geology* **26**, 405-410 (1989).

Napier, B.A., J.C. Simpson, P.W. Eslinger, J.V. Ramsdell, Jr., M.E. Thiede, and W.H. Walters, *Validation of HEDR Models*, PNWD-2221 HEDR, Battelle Pacific Northwest Laboratories, Richland, Washington (1994).

Farris, W.T., B.A. Napier, T.A. Ikenberry, J.C. Simpson, and D.B. Shipler, *Atmospheric Pathway Dosimetry Report, 1944-1992, Hanford Environmental Dose Reconstruction Project*, PNWD-2228 HEDR, Battelle Pacific Northwest Laboratories, Richland, Washington (1994).

Farris, W.T., B.A. Napier, J.C. Simpson, S.F. Snyder, and D.B. Shipler, *Columbia River Pathway Dosimetry Report, 1944-1992, Hanford Environmental Dose Reconstruction Project*, PNWD-2227 HEDR, Battelle Pacific Northwest Laboratories, Richland, Washington (1994).

Shipler, D.B., and B.A. Napier, *HEDR Modeling Approach*, PNWD-1983 HEDR Rev. 1, Battelle Pacific Northwest Laboratories, Richland, Washington (1994).

Napier, B.A., *Uncertainty/Sensitivity Analyses for Atmospheric Pathway Doses*, PNWD-SA-4054 S HEDR, Battelle Pacific Northwest Laboratories, Richland, Washington (1994).

Napier, B.A., *Determination of Key Radionuclides and Parameters Related to the Dose from the Columbia River Pathway*, BN-SA-3768 HEDR, Pacific Northwest Laboratories, Richland, Washington (1993).

Napier, B. A, R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, *HANFORD ENVIRONMENTAL DOSIMETRY UPGRADE PROJECT. GENII - The Hanford Environmental Radiation Dosimetry Software System. Volume 1: Conceptual Representation, Volume 2: Users' Manual. Volume 3: Code Maintenance Manual.* PNL-6584, Vols. 1-3, Pacific Northwest Laboratory, Richland, Washington (1988).

CURRICULUM VITAE

Name: **André Bouville**

Date of Birth: June 12, 1939

Place of Birth: Toulouse, France

Citizenship: U.S.A.

Marital Status: Married, 1966; two children

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Education:
Université Paul-Sabatier, Toulouse, France, 1960 B.S. (eq.) (Physics)
Université Paul-Sabatier, France, 1963 M.S. (eq.) (Nuclear Physics)
Université Paul-Sabatier, France, 1970 Ph.D. (eq.) (Physics)

Professional Experience:

1984-present: Expert, Senior Radiation Physicist, NIH, NCI, DCE, Radiation Effects Branch.
1972-1984: Physicist, Group Chief, Division Deputy Director, Assistant to the Director of Protection, French Atomic Energy Commission, Fontenay-aux-Roses, France.
1970-1972: Scientific Secretary, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), New York, NY.

Honors:
Consultant, United Nations Scientific Committee on the Effects of Atomic Radiation.
Member, Committee 2 of the International Commission on Radiological Protection.
Member, National Council on Radiation Protection and Measurements.
Member, Committee on an Assessment of CDC Radiation Studies of the National Research Council.
Chevalier, Ordre des Palmes Académiques, France.

Field of Interest: Radiation Dosimetry and Environmental Transfer of Radionuclides

Scientific Publications: The author and co-author of more than 100 publications and Committee reports. Among these are the following:

A. Bouville, M. Dreicer, H.L. Beck, and B.W. Wachholz. "Assessment of Iodine-131 transfer to cow's milk and to man resulting from the Nevada weapons tests of the 1950's." *Seventh International Congress of the IRPA. Radiation Protection Practice.* pp. 1387-1390, Pergamon Press, 1988.

M. Dreicer and B.W. Wachholz. "Transfer of Iodine-131 from deposition to milk: estimation of pasture intake." *Seventh International Congress of the IRPA. Radiation Protection Practice.* pp. 1383-1386. Pergamon Press, 1988.

M. Dreicer and A. Bouville. "Methodology to assess the Iodine-131 transferred to cow's milk as a result of the Nevada nuclear weapons tests of the 1950's." *Berichte der Naturwissenschaftlich-Medizinischen Vereinigung in Salzburg* **9**, 165-167 (1988).

B.G. Bennett and A. Bouville. "Radiation doses in countries of the Northern Hemisphere from the Chernobyl nuclear reactor accident." *Environment International* **14**,75-82 (1988).

A. Bouville, M. Dreicer, H.L. Beck, W.M. Hoecker and B.W. Wachholz. "Models of radioiodine transport to populations within the continental U.S." *Health Physics* **59**, 659-668 (1990).

M. Dreicer, A. Bouville and B.W. Wachholz. "Pasture practices, milk distribution, and consumption in the continental U.S. in the 1950's." Health Physics **59**, 627-636 (1990).

H. Beck, I.K. Helfer, A. Bouville and M. Dreicer. "Estimates of fallout in the continental U.S. from Nevada weapons testing based on gummed-film monitoring data." *Health Physics* **59**, 565-576 (1990).

A. Bouville, K. Eckerman, W. Griffith, O. Hoffman, R. Leggett and J. Stubbs. "Evaluating the reliability of biokinetic and dosimetric models and parameters used to assess individual doses for risk assessment purposes." *Radiation Protection Dosimetry* **53**, 211-215 (1994).

A. Bouville "The Chernobyl accident." *Radiation Protection Dosimetry* **60**, 287-293 (1995).

D.V. Becker, J. Robbins, G.W. Beebe, A.C. Bouville and B.W. Wachholz. "Childhood thyroid cancer following the Chernobyl accident - A status report." *Endocrinology and Metabolism Clinics of North America* **25**, 197-211 (1996).

I.A. Likhtarev, L.N. Kovgan, S.E. Vavilov, R.R. Gluvchinsky, O.N. Perevoznikov, L.N. Litvinets, L.R. Anspaugh J.R. Kercher and A. Bouville. "Internal Exposure from the Ingestion of Foods Contaminated by ^{137}Cs after the Chernobyl Accident." *Health Phys.* **70**, 297-317 (1996).

CURRICULUM VITAE

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Education:
B.S. Physics/Math., Ball State University, Muncie, Indiana, 1966
M.S. in Meteorol., University of Michigan, Ann Arbor, Michigan, 1967
Ph.D. in Radiation Health Physics, Purdue University, West Lafayette, Indiana, 1973

Professional Experience:
1992-Present: Chief, Environmental Dosimetry Section, CDC
1986-1992: Staff, Illinois Department of Nuclear Safety, Springfield, Illinois
1976-1986: Research Staff, Oak Ridge National Laboratory, Oak Ridge, Tennessee
1967-1976: Faculty, Anderson University, Anderson, Indiana

Professional Affiliations:
Member, National Council on Radiation Protection and Measurements, 1994-Present
Plenary Member, Health Physics Society and American Meteorological Society

Field of Interest: Environmental transport and dosimetry of radionuclides

Scientific Publications: Have authored or co-authored over 100 scientific papers, technical reports, and meeting proceedings papers related to environmental transport and dosimetry and dose reconstruction. Among them are the following:

Miller, C. W., "An Analysis of Measured Values for the Fraction of A Radioactive Aerosol Intercepted by Vegetation," *Health Phys.* **38**, 705-712 (1980).

Miller, C. W., S. J. Cotter, C. A. Little, and R. E. Moore, "Comparison of Observed and Predicted Doses from the TMI Incident," *Trans. Am. Nucl. Soc.* **34**, 90-91 (1980).

Miller, C. W., "Comparison of Methods for Predicting Air Concentrations Near Reactor Complexes," *Trans. Am. Nucl. Soc.* **39**, 125-126 (1981).

Miller, C. W. and F. O. Hoffman, "An Examination of the Environmental Half-Time for Radionuclides Deposited on Vegetation," *Health Phys.* **45**, 731-744 (1983).

Hoffman, F. O. and C. W. Miller, "Uncertainties in Environmental Radiological Assessment Models and Their Implications," in *Environmental Radioactivity*, Proceedings of the Nineteenth Annual Meeting of the National Council on Radiation Protection Measurements, Washington, D.C., April 6, 1983, Proceedings No. 5 (1983).

Fields, D. E., C. W. Miller, and S. J. Cotter, "Validation of the AIRDOS-EPA Computer Code by Simulating Intermediate Range Transport of 85Kr from the Savannah River Plant," *Atoms. Environ.* **18**, 2029-2036 (1984).

Miller, C. W. and L. M. Hively, "A Review of Validation Studies for the Gaussian Plume Atmospheric Dispersion Model," *Nucl. Safety* **28**, 522-531 (1987).

Miller, C. W., W. D. Cottrell, J. M. Loar, and J. P. Witherspoon, "An Evaluation of the Impact of Radioactive Liquid Effluent Releases from the Rancho Seco Nuclear Power Plant, " *Health Phys.* **58**, 263-274 (1987).

Miller, C. W., J. M. Smith, and L. S. Denham, "Dose Reconstruction Studies at Selected Nuclear Weapons Facilities in the U. S. A.," *Assessing the Radiological Impact of Past Nuclear Activities and Events*, IAEA-TECDOC-755, International Atomic Energy Agency, Vienna, Austria (1994).

Miller, C. W., J. M. Smith, and R. C. Whitcomb, "Application of Environmental Dose Reconstruction to the Assessment of Present and Future Risks," *Topical Meeting Proceedings, Environmental Radiation: How Clean is Clean?*, Springfield, Illinois, October 11-14, 1994, Prairie State Chapter of the Health Physics Society, Springfield, Illinois, pp. 2-11 to 2-15 (1994).

Nair, S. K., C. W. Miller, K. M. Thiessen, and E. K. Garger, "Modeling the Resuspension of Radionuclides in Ukrainian Regions Impacted by Chernobyl Fallout, " *Health Phys.* (In press).

Miller, C. W., and J. M. Smith, "Why Do Environmental Dose Reconstructions?," *Health Phys.* (In press).

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Tel (3512) 654-734.

Education: 1984-1989 Chelyabinsk Technical University, Russia

Professional Experience: 1991 to present staff member of Urals Research Center for Radiation Medicine, URCRM (former Chelyabinsk Branch of Moscow Biophysics Institute)
1991-1993: engineer of biophysics laboratory of URCRM
1993 to present: researcher of biophysics laboratory.
1995 Visiting-Scientist, Institute for Radiation Hygiene (BfS) and Institute for Radiation Protection (GSF), Munich, Germany. (2 months)

Field of Interest: Thermoluminescent dosimetry and dating, theoretical and experimental problems of dose field reconstruction using ceramic samples from accidentally polluted areas.

Scientific Publications:

Bougrov, N.G., Vlasov, V.K., Kiryukhin, O.V., and Fatkulbayanova, N.L., Thermoluminescence measurements of ceramic samples from accidentally polluted territory of Southern Urals. *Radiat. Measurements* **24**, 493-498 (1995).

Degteva, M.O., Kozheurov, V.P., Burmistrov, D.S., Vorobyova, M.I., Valchuk, V.V., Bougrov, N.G., and Shishkina, E.A., Dose reconstruction for the Southern Urals population. *Health Phys.* (in press).

Goeksu, Y., Heide, L.M., Bougrov, N.G., Dalheimer, A.R. and Meckbach, R., Retrospective dose assessment and dose depth distribution in a brick from South Ural by using thermoluminescence. *Appl. Radiat. Isot.* (in press).

Bougrov, N.G., Vlasov, V.K., Kiryukhin, O.V., and Fatkulbayanova, N.L., Application of TL measurements of ceramic samples in retrospective dosimetry for external dose reconstruction on the Techa River. In *Proceedings of 11th International Conference on Solid State Dosimetry held in Budapest 10-14th July 1995*, pp. 60-61.

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Tel (3512) 654-608.
Education: 1977-1982 Dept. of Physics, Chelyabinsk State University, Russia
Scientific Degree: Ph.D. in 1995, St. Petersburg University, Mathematics and Mechanics department. Specialty title "Theoretical Basis of Mathematical Modeling, Numeric Methods and Program Packages."
Professional Experience:

1983-1986 Assistant Professor of Physics Department, Chelyabinsk High Military Aviation School, Chelyabinsk, Russia;
1987-1990 Postgraduate Student on nuclear and particle physics, Tomsk Polytechnical Institute, Tomsk, Russia.
1991-1993 Researcher of Biophysics Laboratory, URCRM (former FIB4), Chelyabinsk, Russia;
1993-Present Senior Researcher of Biophysics Laboratory, URCRM, Chelyabinsk, Russia.

Field of Interest: Radioecology, Radiation Dosimetry and Microdosimetry, Mathematical Modeling, Radiation Transport Calculations.

Scientific Publications: more then 30 publications, among them

Lappa, A.V., Burmistrov, D.S., Vasilyev, O.N., Calculation of Microdosimetric Characteristics of Electron-Photon Radiation by the Fluctuation Detector Method Using Electron Condensed Collision Model. In: Mikrodozimetriya i prilogeniya v Radiobiologii, Moskva: MIFI, 1988, pp. 120-124. (In Russian).

Lappa, A.V., Burmistrov, D.S., Method of Calculation of Fluctuations in Defects Visualization in Introscopic and Radiographic systems. Defectoscopiya. Defektoskopiya, 1989, N11, 29-38. (In Russian).

Lappa, A.V., Bigildeev, E.A., Burmistrov, D.S., Vasilyev, O.N., "Trion" Code for Radiation Action Calculations and Its Application in Microdosimetry and Radiobiology. *Radiat. Environ. Biophys.* **32**, 1-19.(1993)

Lappa, A.V., Burmistrov, D.S., CASCADE-5 Monte Carlo Code for Calculation of Average and Fluctuation Characteristics of Electron-Photon Transport. In: *Proc. of 8th International Conference on Radiation Shielding.- Arlington, Texas (USA),* 1994,.V.2, pp. 1338-1345.

Burmistrov, D.S., Vorobiova, M.I., Elaboration of System of Retrospective Dose Estimation for External Irradiation of the Techa Riverside Residents. In: *Proceedings of the 1st Int. Symp. "Chronic Radiation Exposure: Risk of Late Effects". Chelyabinsk, 1995.*

CURRICULUM VITAE

Name: **Edwin H. Haskell**

Date and place of birth: November 21st, 1946, Dillon, Montana, U.S.A.

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Education:
University of Utah, 1987 M.S. (Instrumentation Physics)
University of California at Santa Cruz, 1978 Ph.D. (Biology)
University of California at Santa Cruz, 1975 M.A. (Biology).
University of California at Santa Cruz, 1969 A.B. (Biology).

Professional Experience:

1995-Present: Director, Center for Applied Dosimetry, U of Utah
1984-Present: Research Assistant Professor, Radiobiology Division, University of Utah.
1979-1984: Research Instructor, Department of Pharmacology, Radiobiology Division, University of Utah. Head, Thermoluminescence Laboratory.
1969-1972: Lecturer in Biology, South Pacific Regional College of Tropical Agriculture, Apia, Western Samoa (U.S. Peace Corps).

Field of Interest: Radiation dosimetry using environmental materials.

Scientific Publications: The author and co-author of over 35 scientific papers related to radiation dosimetry using solid state techniques on environmental materials in addition to six papers currently submitted or accepted for publication:

Polyakov, V. I., E. H. Haskell, G.H. Kenner, G. Hutt and R. B. Hayes, Effect of mechanically induced background signal on EPR-dosimetry of tooth enamel. *Radiat. Meas.* **24**(3), 249-254 (1995).

Haskell, E. H., G. H. Kenner, and R. B. Hayes, Electron paramagnetic resonance dosimetry of dentine following removal of organic material, *Health Phys.* **68**, 579-584 (1995).

Haskell, E. H., I. K. Bailiff, G. H. Kenner, P. L. Kaipa and M. E. Wrenn, Thermoluminescence measurements of gamma-ray doses attributable to fallout from the Nevada Test Site using building bricks as natural dosimeters, *Health Phys.* **66**, 380-391 (1994).

Wieser, A., E. Haskell, G. Kenner and F. Bruenger, EPR Dosimetry of bone gains accuracy by isolation of calcified tissue, *Appl. Radiat. Isot.* **45**, 525-526 (1994).

Godfrey-Smith, D. I. and E.H. Haskell, Application of optically stimulated luminescence to the dosimetry of recent radiation events involving low total absorbed doses, *Health Phys.* **65**, 396-404 (1993).

Hütt, L. Brodski, D. Stoneham, H. Jungner, I. Bailiff, Y. Goksu and E. Haskell, Accident dosimetry using environmental materials collected from regions downwind of Chernobyl, *Radiat. Protect. Dosim.* **47**, 307-311 (1993).

Haskell, E.H., Retrospective accident dosimetry using environmental materials, *Radiat. Protect. Dosim.* **47**, 297-303 (1993).

Stoneham, D., I. K. Bailiff, C. Brodski, G. Hütt, Y. Goksu, E. Haskell, H. Jungner and T. Nagatomo, TL accident dosimetry measurements on samples from the town of Pripyat, *Nucl. Tracks & Radiat. Meas.* **21**, 195-200 (1993).

Haskell, Edwin H., Accident dosimetry using environmental materials, *Nucl Tracks & Radiat. Meas.* **21**, 87-93 (1993).

Huntley, D. J., D.I. Godfrey-Smith and E.H. Haskell, Light-induced emission spectra from some quartz and feldspars, *Nucl. Tracks Radiat. Meas.* **18**, 127-131 (1991).

Haskell, Edwin H. and Ian K. Bailiff, TL dosimetry using bricks and tiles for measurement of transient gamma ray dose in inhabited areas, *Radiat. Protect. Dosim.* **34**, 195-197 (1990).

Haskell, E.H., P.L. Kaipa and M.E. Wrenn, Pre-dose TL characteristics of quartz inclusions removed from bricks exposed to fallout radiation from atmospheric testing at the Nevada Test Site, *Nucl. Tracks and Radiat. Meas.* **14**, 114-120 (1988).

Haskell, E.H., P.L. Kaipa and W.H. Ellett, Interlaboratory calibration using NBS-irradiated Mg2SiO4:Tb. In: W. Roesch (Ed.) *U.S. Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry In Hiroshima and Nagasaki, Final Report,* Vol. II (1988).

Haskell, E.H. The Use of Thermoluminescence, *Proceedings of the 23rd Annual Meeting of the NCRP, 8-9 April 1987.*

Maruyama, T., Y. Kumamoto, Y. Ichikawa, T. Nagatomo, M. Hoshi, E. Haskell and P. Kaipa, Thermoluminescence Measurements of Gamma Rays. In: W. Roesch (Ed.) *U.S. Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry In Hiroshima and Nagasaki, Final Report,* Vol. I (1987).

CURRICULUM VITAE

Name: **Alexander N. Kovtun**

Year and place of birth: November 16, 1941, St. Petersburg, Russia

Citizenship: Russian Federation

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Phone: 7 (812) 267 35 29

Education: 1961-1966 Leningrad State University,
St. Petersburg, Russia

Scientific degree: Ph.D., 1978, Thesis titled "Determination of whole gamma irradiated radionuclides contents with non-uniform distribution in human body"

Professional experience:

1967-1978 Member of Staff of Research Institute for Industrial and Naval Medicine, St. Petersburg, Russia

1978-Present Senior Scientist, Head of Group for Internal Radiation Dosimetry

Scientific publications and patents: Author and co-author of 75 scientific-technical reports and papers. Among them are the following:

Degteva, M.O., Kozheurov, V.P., Tolstykh, Y.I., and Kovtun, A.N., The measuring and modeling of Sr-90: An integrated retrospective dosimetry issue. 1996 International Congress on Radiation Protection (IRPA9). Vol. 1. pp. 417-424; Vienna, Austria, 1996

Kovtun, A.N. Phantoms and Computational Models in Therapy, Diagnosis and Protection. *ICRU Report 48*, 1992. Appendix B. Specifications of Phantoms. p. 77.

Griffith, R. Kovtun, A.N., et al., IAEA-USSR Whole Body Counter intercomparison. Report at the 8th International Congress of the International Radiation Protection Association (IRPA8), Montreal, Canada, 1992.

Belle, Y.S., Kovtun, A.N., Kozheurov, V.P. et al., Human radiation spectrometer for measuring low content of incorporated Sr-90. *Med. Radiol.* **20**, 52-58 (1975) (In Russian).

Method of Whole Body Counter Calibration. Patent 1849873 (1980).

Equipment for Whole Body Counter Calibration. Patent 195105768/25 (010281) (1995).

CURRICULUM VITAE

Name: **Vyacheslav P. Kozheurov**

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Phone +7 (3512) 186-299.

Education: 1963-1968 Dept. of Physics, Kharkov State University, Ukraine.

Professional Experience: 1969-Present: Staff Member of Urals Research Center for Radiation Medicine, URCRM, former Branch No 4 of Moscow Biophysics Institute
1969-1986: Junior Scientist of Physics Laboratory;
1986-1990: Senior Physical Engineer of Clinical Department;
1991-Present: Senior Researcher of Biophysics Laboratory.

Field of Interest: Radiation dosimetry and risk assessment.

Scientific Publications: The author and co-author of over 50 scientific papers and technical reports related to the dose assessment and biological effects of radiation. Among them are the following:

Kozheurov, V.P., SICH-9.1-a unique whole-body counting system for measuring Sr-90 via bremsstrahlung. The main results from a long-term investigation of the Techa River population, *Science Total Environ.* **142**, 37-48 (1994).

Kozheurov, V.P., and Degteva, M.O., Dietary Intake Evaluation and Dosimetric Modelling for the Techa River Residents Based on in vivo Measurements of Strontium-90 in Teeth and Skeleton, *Science Total Environ.* **142**, 63-72 (1994).

Degteva, M.O., Kozheurov, V.P., Vorobiova, M.I., General Approach to Dose Reconstruction in the Population Exposed as a Result of the Release of Radioactive Wastes into the Techa River, *Science Total Environ.* **142**, 49-62 (1994).

Degteva, M.O., and Kozheurov, V.P., Age-dependent Model for Strontium Retention in Human Bone, *Radiat. Protect. Dosimetry* **53**, 229-234 (1994).

Degteva, M.O., Kozheurov, V.P., Tolstykh, E.I., Kovtun, A.N., The Measuring and Modelling of Strontium-90: an Integrated Retrospective Dosimetry Issue, IRPA9: 1996 International Congress on Radiation Protection. Vienna, Austria, April 14-19, 1996. Vol. 1., p. 417-424.

Romanyukha, A.A., Ignatiev, E.A., Degteva, M.O., Kozheurov, V.P. et al., Retrospective Dosimetry for Survivors after Ural Waste Accidents. *Nature*. (in press).

Romanyukha, A.A., Degteva, M.O., Kozheurov, V.P. et al., Pilot Study of the Population of the Ural Region with EPR Tooth Dosimetry. Radiat. Environ. Biophys. (in press).

CURRICULUM VITAE

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Address: (home) 11, Novgorotsevoi St., Apt. 30, Ekaterinburg 620072, Russia

Education: 1972-1978 Physics Department, Ural Technical University, Ekaterinburg, Russia

Scientific Degree: Ph.D., 1985, Thesis titled "Experimental investigation of surface dynamics of conduction electrons in metal films by EPR"

Professional Experience:

Director, EPR Spectroscopy Center, Institute of Metal Physics, Russian Academy of Sciences, November 1987 to present.

Guest-scientist at GSF-Forschungszentrum fur Umwelt und Gesundheit, Institute fur Strahlenschutz, Neuherberg, 85764 Oberschleisheim, Germany, September 1993, July 1994 to November 1994, April 1995 to October 1995.

Senior Scholar at Surface Laboratory, Physics Department, Simon Fraser University, Burnaby, Canada, May 1989 to October 1989.

Senior Scientist, Institute of Metal Physics, Academy of Sciences of the USSR, August 1987 to November 1987.

Scientist, Institute of Metal Physics, Academy of Sciences of the USSR, July 1986 to August 1987.

Junior Scientist, Institute of Metal Physics, Academy of Sciences of the USSR, June 1979 to July 1986.

Field of Interest: EPR investigations of radiation effects in solid state.

Scientific publications: Co-author of over 80 scientific publications in the field of EPR, 14 of them in the field of the present proposal.

List of Recent Publications:

Romanyukha, A.A., Regula, D., Vasilenko, E., and Wieser, A., South Ural Nuclear Workers: Comparison of Individual Doses from Retrospective EPR Dosimetry and Operating Personal Monitoring, *Appl. Radiat. Isotopes* **45**, 1195-1199 (1994).

Romanyukha, A.A., and Regula, D., Aspects of Retrospective Dosimetry. *Appl. Radiat. Isotopes.* (in press)

Romanyukha, A.A., Regula, D., Vasilenko, E., Wieser, A., Drozhko, E.G., Lyzlov, A.F., Koshurnikova, N.A., Shilnikova, N.S. and Panfilov A.P., Retrospective dosimetry of electron paramagnetic resonance with teeth of Russian nuclear workers. *Appl. Radiat. Isotopes* (in press).

Romanyukha, A.A., Wieser, A. and Regula, D., EPR dosimetry with different biological and synthetic carbonated materials. *Radiat. Protect. Dosim.* (in press).

CURRICULUM VITAE

Name: **Evgenia I. Tolstykh**

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Address: (home) 2-7 Vorovskogo St., Chelyabinsk, 454092, Russia
Tel (3512) 375-096.

Education: 1978-1983 Biological Department, Urals State University, Russia

Scientific Degree: Ph.D. in 1996 Chelyabinsk Pedagogical University, Specialty title "Physiology of man and animals."

Professional Experience:

1985-1986: Teacher of Department of Physiology and Anatomy in Chelyabinsk Pedagogical Institute
1986-Present: Staff Member of Urals Research Center for Radiation Medicine, URCRM (former Chelyabinsk Branch of Moscow Biophysics Institute)
1986-1989: Assistant at Experimental Department
1989-1993: Junior Researcher at Experimental Department
1993-1996: Researcher at Experimental Department
1996-Present: Researcher of Biophysics Laboratory.

Field of Interest: Radiobiology, chemical radioprotection, calcium and strontium metabolism.

Scientific Publications: Author and co-author of over 15 scientific publications and technical reports. Among them are the following:

Tolstykh, E.I., and Korytny, V.S., The effects of different dose rate exposure on survives and critical systems of organism of mice, *Radiobiologia* 788-794 (1993) (in Russian).

Degteva, M.O., Kozheurov, V.P., Tolstykh, E.I., and Kovtun, A.N., The Measuring and Modeling of Strontium-90: an Integrated Retrospective Dosimetry Issue. IRPA9: 1996 International Congress on Radiation Protection. Vienna, Austria, April 14-19, 1996. Vol. 1., p. 417-424.

Tolstykh, E.I., Kozheurov, V.P., Vyushkova, O.V., and Degteva, M.O., Analysis of excretion of 90-Sr in residents of the Techa river area, *Radiat. Environ. Biophys.* (in press).

CURRICULUM VITAE

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Address: *(office)*	39-69 Engelsa St., Chelyabinsk, 454080, Russia Tel: (3512) 654-734.

Education:	1979-1984 Dept. of Physics, Chelyabinsk State University, Russia
Professional Experience:	1984-Present: Staff Member of Urals Research Center for Radiation Medicine, URCRM (former Chelyabinsk Branch of Moscow Biophysics Institute) 1984-1986: Engineer of Radiation Hygiene Laboratory of URCRM 1986-1991: Junior Researcher of Radiation Hygiene Laboratory; 1986-1988: Temporary Work in Belarus in connection with Chernobyl accident; 1991-Present: Researcher of Biophysics Laboratory.
Field of Interest:	Radioecology and radiation dosimetry.

Scientific Publications:

Degteva, M.O., Kozheurov, V.P., and Vorobiova, M.I., Dose Reconstruction for the Population Exposed Due to Radioactive Waste Releases into the Techa River, *Atomnaya Energiya (Atomic Energy)* **72**, 386-390 (1992) (in Russian).

Degteva, M.O., Kozheurov, V.P., and Vorobiova, M.I., General Approach to Dose Reconstruction in the Population Exposed as a Result of the Release of Radioactive Wastes into the Techa River, *Science Total Environ.* **142**, 49-62 (1994).

Burmistrov, D.S., and Vorobiova, M.I., Elaboration of System of Retrospective Dose Estimation for External Irradiation of the Techa Riverside Residents. *Proceedings of the 1st Int. Symp. "Chronic Radiation Exposure: Risk of Late Effects". Chelyabinsk, 1995.*

Romanyukha, A.A., Degteva, M.O., Seregenkov, V.A., Kozheurov, V.P., Vorobiova, M.I., Vasilenko, E.A., Wieser, A., Kleshchenko, E.D., Shishkina, E.A., Khokhryakov, V.F., Individual Dose Reconstruction for Ural Residents Based on Electron Spin Resonance Signal of Teeth, *Proceedings of the 1st Int. Symp. "Chronic Radiation Exposure: Risk of Late Effects". Chelyabinsk, 1995.*

Romanyukha, A.A., Degteva, M.O., Kozheurov, V.P., Wieser, A., Jacob, P., Vorobiova, M.I., Ignatiev, E.A., Shishkina, E.A., and Koshta, A.A., Retrospective Evaluation of the External Component of Individual Doses for Techa Riverside Residents, *Proceedings of 1996 International Congress on Radiation Protection, Vienna, Austria, 14-19 April, 1996.*

APPENDIX C:

DETAILED BUDGET INFORMATION

					BUDGET SUMMARY		
Project Title: Dose Reconstruction for the Urals Populuation		Period of Support:		YEAR 1	YEAR 2	YEAR 3	YEAR 4
Institution: Lawrence Livermore National Laboratory							
Complete Address: Battelle Pacific Northwest Laboratories							
University of Utah							
Urals Research Center for Radiation Medicine (URCRM)							
Mayak Industrial Association (MIA)							
Special Major Procurement							
Name of Principal Investigator: Lynn Anspaugh		Telephone: 510-424-6409 / 424-6410					
		Fax: 510-424-6408					
Requested Items							
A. Equipment				**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list description of equipment							
1 Misc Computer/Software				15,000	15,600	16,224	16,873
2 Modernization URCRM Sr-90 Whole-Body Counter				245,000			
3 Electron Paramagnetic Resonance Spectrometer—Institute of Metal Physics				200,000			
4 Mayak Equipment/Supplies				20,000			
5 MPC Charges				31,390	250	260	270
Please justify equipment purchase on separate page(s)			**Subtotal>**	511,390	15,850	16,484	17,143
B. Supplies (Itemize)				**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 TID/Print/Journals				2,000	2,080	2,163	2,250
2 Subcontract/Consulting & OHC				4,972	5,171	5,378	5,593
3 Telephone				400	416	433	450
4 Misc Supplies				2,994	3,114	3,238	3,368
5 Equipment Maintenance				2,500	2,600	2,704	2,812
Please justify equipment purchase on separate page(s)			**Subtotal>**	12,866	10,781	11,212	11,660
C. Estimate Travel Costs	Destination		Travel Dates	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of travellers							
1 Travel for Livermore Personnel	Domestic			6,000	6,240	6,490	6,749
2 Travel for Livermore Personnel	Foreign			16,000	16,640	17,306	17,998
3 2 Trips to Chelyabinsk/2 Trips to DC/1 Trip Livermore				16,039	16,681	17,348	18,042
4 Misc Travel-U of Utah				3,268	3,399	3,535	3,676
5 Misc Travel-Mayak				20,000			
Please report justification for travel on separate page(s)			**Subtotal>**	61,307	42,959	44,678	46,465
Personnel and Other Costs							
D. i) Project Personnel costs	**% Effort**			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of staff members							
1 L. Anspaugh		0.25		25,742	26,772	27,843	28,956
2 J. Kercher		0.40		29,458	30,636	31,862	33,136
3 Additional Scientist		0.05		3,319	3,452	3,590	3,733
4 Research Scientists/Engineers				32,877	34,192	35,560	36,982
5 Clerical/Secretarial				762	792	824	857
6 E. Haskell		0.10		6,044	6,286	6,537	6,799
7 G. Kenner		0.10		3,750	3,900	4,056	4,218
8 R. Hayes		0.25		6,625	6,890	7,166	7,452
9 R. Diffley		0.13		1,875	1,950	2,028	2,109
10 Mayak Salaries				50,000			
11 Fringe Benefits				28,626	29,771	30,962	32,200
12 Facility Charges (LFC/OFC)				9,800	10,192	10,600	11,024
Please list duties of each staff on separate pages(s)		1.28	**Subtotal>**	198,878	154,833	161,026	167,468
D. ii) Other Costs/Indirect Costs				**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Indirect Costs				249,962	192,020	199,701	207,689
2							
3							
			Subtotal>	249,962	192,020	199,701	207,689
			Total Costs	1,034,403	416,443	433,101	450,425

Project Title: Dose Reconstruction for the Urals Popuation		Period of Support:	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Institution: Lawrence Livermore National Laboratory						
Complete Address: P.O. Box 808 Livermore, CA 94550						
Name of Principal Investigator: Lynn Anspaugh		Telephone: 510-424-6409 / 424-6410 Fax: 510-424-6408				
Requested Items						
A. Equipment			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list description of equipment						
1 Misc Computer/Software			15,000	15,600	16,224	16,873
2						
3						
4 MPC Charges			240	250	260	270
Please justify equipment purchase on separate page(s)		**Subtotal>**	15,240	15,850	16,484	17,143
B. Supplies (Itemize)			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 TID/Print/Journals			2,000	2,080	2,163	2,250
2						
3						
4						
Please justify equipment purchase on separate page(s)		**Subtotal>**	2,000	2,080	2,163	2,250
C. Estimate Travel Costs	Destination	Travel Dates	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of travellers						
1	Domestic		6,000	6,240	6,490	6,749
2	Foreign		16,000	16,640	17,306	17,998
3						
4						
Please report justification for travel on separate page(s)		**Subtotal>**	22,000	22,880	23,795	24,747
Personnel and Other Costs						
D. i) Project Personnel costs	% Effort		**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of staff members						
1 L. Anspaugh	0.25		25,742	26,772	27,843	28,956
2 J. Kercher	0.40		29,458	30,636	31,862	33,136
3 Additional Scientists	0.05		3,319	3,452	3,590	3,733
4						
5 Fringe Benefits			22,589	23,493	24,432	25,410
6 Facility Charges (LFC/OFC)			9,800	10,192	10,600	11,024
Please list duties of each staff on separate pages(s)	0.70	**Subtotal>**	90,908	94,544	98,326	102,259
D. ii) Other Costs/Indirect Costs			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Indirect Costs			130,092	135,296	140,708	146,336
2						
3						
		Subtotal>	130,092	135,296	140,708	146,336
		Total Costs	260,240	270,650	281,476	292,735

Project Title: Dose Reconstruction for the Urals Populuation		Period of Support:	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Institution: Battelle Pacific Northwest Laboratories						
Complete Address: P.O. Box 999 Richland, WA 99352						
Name of Principal Investigator: Bruce Napier		Telephone: 509-375-2019 Fax: 509-375-3896				
Requested Items						
A. Equipment			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list description of equipment						
1						
2						
3						
4 MPC Charges						
Please justify equipment purchase on separate page(s)		**Subtotal>**	0	0	0	0
B. Supplies (Itemize)			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Subcontract/Consulting & OHC			4,972	5,171	5,378	5,593
2						
3						
4						
Please justify equipment purchase on separate page(s)		**Subtotal>**	4,972	5,171	5,378	5,593
C. Estimate Travel Costs	Destination	Travel Dates	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of travellers						
1 2 Trips to Chelyabinsk/2 Trips to DC/1 Trip Livermore			16,039	16,681	17,348	18,042
2						
3						
4						
Please report justification for travel on separate page(s)		**Subtotal>**	16,039	16,681	17,348	18,042
Personnel and Other Costs						
D. i) Project Personnel costs	% Effort		**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of staff members						
1 Research Scientists/Engineers			32,877	34,192	35,560	36,982
2 Clerical/Secretarial			762	792	824	857
3						
4						
5 Fringe Benefits						
6 Facility Charges (LFC/OFC)						
Please list duties of each staff on separate pages(s)	0.00	**Subtotal>**	33,639	34,985	36,384	37,839
D. ii) Other Costs/Indirect Costs			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Indirect Costs			45,349	47,163	49,049	51,011
2						
3						
		Subtotal>	45,349	47,163	49,049	51,011
		Total Costs	99,999	103,999	108,159	112,485

Project Title: Dose Reconstruction for the Urals Populuation		Period of Support:	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Institution: University of Utah						
Complete Address: 825 North, 300 West Suite 107						
Salt Lake City, UT 84103						
Name of Principal Investigator: Ed Haskell		Telephone: 801-359-5962				
		Fax: 801-359-5862				
Requested Items						
A. Equipment			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list description of equipment						
1						
2						
3						
4 MPC Charges						
Please justify equipment purchase on separate page(s)		**Subtotal>**	0	0	0	0
B. Supplies (Itemize)			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Telephone			400	416	433	450
2 Misc Supplies			2,994	3,114	3,238	3,368
3 Equipment Maintenance			2,500	2,600	2,704	2,812
4						
Please justify equipment purchase on separate page(s)		**Subtotal>**	5,894	6,130	6,375	6,630
C. Estimate Travel Costs	Destination	Travel Dates	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of travellers						
1			3,268	3,399	3,535	3,676
2						
3						
4						
Please report justification for travel on separate page(s)		**Subtotal>**	3,268	3,399	3,535	3,676
Personnel and Other Costs						
D. i) Project Personnel costs	**% Effort**		**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of staff members						
1 E. Haskell	0.10		6,044	6,286	6,537	6,799
2 G. Kenner	0.10		3,750	3,900	4,056	4,218
3 R. Hayes	0.25		6,625	6,890	7,166	7,452
4 R. Diffley	0.13		1,875	1,950	2,028	2,109
5 Fringe Benefits—33%			6,037	6,278	6,530	6,791
6 Facility Charges (LFC/OFC)						
Please list duties of each staff on separate pages(s)	0.58	**Subtotal>**	24,331	25,304	26,316	27,369
D. ii) Other Costs/Indirect Costs			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Indirect Costs @49.5%			16,579	17,242	17,932	18,649
2						
3						
		Subtotal>	16,579	17,242	17,932	18,649
		Total Costs	50,072	52,075	54,158	56,324

Project Title: Dose Reconstruction for the Urals Populuation		Period of Support:	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Institution: Urals Research Center for Radiation Medicine (URCRM)						
Complete Address:						
Name of Principal Investigator: Marina Degteva		Telephone: 011-7-3512-344-351				
		Fax: 011-7-3512-344-321				
Requested Items		*The distribution of the monies will be negotiated by JCCRER*				
A. Equipment			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list description of equipment						
1						
2						
3						
4 MPC Charges						
Please justify equipment purchase on separate page(s)		**Subtotal>**	**0**	**0**	**0**	**0**
B. Supplies (Itemize)			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1						
2						
3						
4						
Please justify equipment purchase on separate page(s)		**Subtotal>**	**0**	**0**	**0**	**0**
C. Estimate Travel Costs	Destination	Travel Dates	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of travellers						
1						
2						
3						
4						
Please report justification for travel on separate page(s)		**Subtotal>**	**0**	**0**	**0**	**0**
Personnel and Other Costs						
D. i) Project Personnel costs	**% Effort**		**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of staff members						
1						
2						
3						
4						
5 Fringe Benefits						
6 Facility Charges (LFC/OFC)						
Please list duties of each staff on separate pages(s)	0.00	**Subtotal>**	**0**	**0**	**0**	**0**
D. ii) Other Costs/Indirect Costs			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Indirect Costs						
2						
3						
		Subtotal>	**0**	**0**	**0**	**0**
		Total Costs	**200,000**	**208,000**	**216,320**	**224,973**

Project Title: Dose Reconstruction for the Urals Populuation		Period of Support:	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Institution: Mayak Industrial Association (MIA)						
Complete Address:						
Name of Principal Investigator: Evgenii Drozhko		Telephone: 011-873-140-4665				
		Fax: 011-351-51-3-38-26				
Requested Items						
A. Equipment			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list description of equipment						
1 Equipment and Supplies			20,000			
2						
3						
4 MPC Charges						
Please justify equipment purchase on separate page(s)		**Subtotal>**	20,000	0	0	0
B. Supplies (Itemize)			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1						
2						
3						
4						
Please justify equipment purchase on separate page(s)		**Subtotal>**	0	0	0	0
C. Estimate Travel Costs	Destination	Travel Dates	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of travellers						
1 Misc Travel			20,000			
2						
3						
4						
Please report justification for travel on separate page(s)		**Subtotal>**	20,000	0	0	0
Personnel and Other Costs						
D. i) Project Personnel costs	% Effort		**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of staff members						
1 Salaries			50,000			
2						
3						
4						
5 Fringe Benefits						
6 Facility Charges (LFC/OFC)						
Please list duties of each staff on separate pages(s)	0.00	**Subtotal>**	50,000	0	0	0
D. ii) Other Costs/Indirect Costs			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Indirect Costs			10,000			
2						
3						
		Subtotal>	10,000	0	0	0
		Total Costs	100,000	0	0	0

Project Title: Special Major Procurement Items for Dose Reconstruction for the Urals Populuation		Period of Support:	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Institution: Lawrence Livermore National Laboratory						
Complete Address: P.O. Box 808 Livermore, CA 94550						
Name of Principal Investigator: Lynn Anspaugh		Telephone: 510-424-6409 / 424-6410 Fax: 510-424-6408				
Requested Items						
A. Equipment			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list description of equipment						
1 Modernization URCRM Sr-90 Whole-Body Counter			245,000			
2 Electron Paramagnetic Resonance Spectrometer—Institute of Metal Physics			200,000			
3						
4 MPC Charges			31,150			
Please justify equipment purchase on separate page(s)		**Subtotal>**	476,150	0	0	0
B. Supplies (Itemize)			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1						
2						
3						
4						
Please justify equipment purchase on separate page(s)		**Subtotal>**	0	0	0	0
C. Estimate Travel Costs	Destination	Travel Dates	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of travellers						
1	Domestic					
2	Foreign					
3						
4						
Please report justification for travel on separate page(s)		**Subtotal>**	0	0	0	0
Personnel and Other Costs						
D. i) Project Personnel costs	**% Effort**		**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
Please list names of staff members						
1						
2						
3						
4						
5 Fringe Benefits						
6 Facility Charges (LFC/OFC)						
Please list duties of each staff on separate pages(s)	0.00	**Subtotal>**	0	0	0	0
D. ii) Other Costs/Indirect Costs			**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**	**Amt in U.S. $**
1 Indirect Costs			47,942			
2						
3						
		Subtotal>	47,942			
		Total Costs	524,092			

APPENDIX D:

RESPONSE TO DRAFT REPORT OF THE SCIENTIFIC REVIEW GROUP

RESPONSE TO DRAFT REPORT OF THE SCIENTIFIC REVIEW GROUP

The draft comments of the first meeting of the American Scientific Review Group (SRG) were received in early April. Unfortunately, due to the schedules of the U.S. and Russian participants there has not been time to consult adequately on responses to this draft report. Thus, the responses provided below must be considered preliminary.

First, it is clear that the timing of the first meeting of the American SRG was most unfortunate in terms of their being able to review plans for the long-term projects. This is because they met on January 30, 1996, whereas the Final Reports from the pilot phases of the projects were not due until February 1996, and the proposals for the long-term work were not due until April 1996. Thus, the material available for their review was minimal, and the SRG did not have an opportunity to interact directly with any of the scientists involved in the projects. Thus, although the draft report states that they "proceeded to review the individual proposals," they did not have in their possession any proposals as such. If the members of the SRG thought that the materials they were given were the proposals, then they must have been very disappointed and the draft report is overly polite.

Data Access

We agree that data access is important to the credibility of the findings, and the experience to date has been very good in terms of the willingness of our Russian colleagues to provide access to their data. The only exception relates to currently classified data pertaining to the operational history of the MIA; such information is important in terms of understanding the magnitude and timing of the releases. We hope that the JCCRER will address this general issue at their next meeting, as it is important that at least our Russian colleagues have access to such data and we should urge that the data be declassified and made available to the extent possible.

For this project, members of the U.S. team will not attempt to have a complete, operational data base in the U.S. There are several reasons for this. First of all, this project is complex, and most of the work on data base structure, additions, and maintenance will have to be done by the Russian scientists. It would take a substantial amount of additional money for the U.S. side to try to maintain an up-to-date operational data base in the U.S. More compellingly, we believe that our current position of trust by our Russian colleagues would be seriously challenged, if they believed that there would be any possible chance of unauthorized use of such data. Such issues were, in fact, a stumbling block to the signing of the original JCCRER agreement, and this block was removed only by the addition of an agreement on intellectual property rights. Our current working agreement is that the U.S. side will have access to the data in Russia, and that any analysis of the Russian data by U.S. scientists will be done jointly with Russian scientists while the U.S. scientists are in Russia. Both the U.S. and Russian scientists are dedicated to the extensive publication of the data and analyses in western peer-reviewed journals.

There is a separate project on data preservation. It is our expectation that this project will ensure the safety of all primary data by securing sufficient duplicate copies in a remote location, so that the data bases can be reconstructed in the event of a disastrous loss.

Project Protocols

We believe that the protocol now provided for this project meets most of the requests of the SRG. One exception is that the current protocol has not addressed the issue of quality control and assurance. There are, in fact, extensive quality-control and -assurance procedures in place and additional procedures will be needed. These procedures and processes will be documented in the future in the context of a separate quality-control and -assurance document.

Principles for Communication

We would prefer that the complete reports of the SRG be available to all participants in the projects. There are many interconnections among the projects, and complete sharing of information would be most useful.

Scope of Project 1.1

The SRG indicated that the scope of the project was too large, although the information upon which this comment was based must have been incomplete. The project participants recognize that it is not possible to examine every pathway. The Final Report on Milestone 1.1.3 addressed this problem, and we have made our best judgments on which pathways are major and which are minor. Thus, we have already done our best to narrow the scope of the project to a manageable level, and we have already made our own determination of the priority to be given to the three cohorts of interest. We agree with the implied suggestion of the SRG that first priority be given to the Techa River Cohort and that the river pathway is of critical importance.

We understand the fears expressed by the SRG that the scope of the work to be done, even after the narrowing of its focus, is enormous and will require a very large scale effort. In fact, if it were not for the very large volume of work already done by our Russian colleagues over many years, the U.S. participants would probably state that the proposed dose reconstruction would not be realistic. However, there is a large volume of directly applicable information based on measurements of body burdens, environmental dosimeters, and other pertinent data. At the present time there are already dose estimates available on a per village basis for the Techa River Cohort; we are seeking to refine these estimates by ensuring the inclusion of all major pathways and by determining individual doses. Individual-dose determinations in some cases have the nature of an on-off switch, such as knowledge of whether a person or family was using water from a well or from the Techa River.

Application of U.S. Experience

We agree that the methods developed for dose reconstruction in the U.S. can have useful application in this study. Each of the U.S. Principal Investigators has been a principal in one or more of the U.S. dose-reconstruction studies, and that was the primary reason for their selection for work on this project. With the inclusion of the members of the SRG, virtually all U.S. experience in major dose reconstruction is available for participation in and advice to this project.

Biomarkers

Work has already been done on biomarkers by the scientists at the URCRM. The results have not been encouraging, as no detectable difference in people with presumed high and low exposures was reported. We have examined in cursory fashion the results of the study done with the FISH technique of examining stable chromosome translocations. We believe that the work suffered from lack of consideration of variation in background rate of translocations with age, and that an insufficient number of cells were scored. Our proposed initial step is to convene a small working group of experts from three countries to examine these results in detail and to propose a precisely defined case study to be conducted under highly controlled conditions. Such a case study would include only individuals for whom there is some reasonably assured basis of dose determination by other means. If the case study is successful, then the method would be more broadly applied to solve other pressing problems.

Members of the U.S. side favor strongly that the biomarker work emphasize the FISH technique. However, the Russian scientists have already done some work with other techniques.

Management Plan, Milestones, and Timeline

We believe that this information is adequately covered in the current protocol, which was unavailable to the members of the SRG at the time of their meeting.